A Study of Archaeological Predictive Modelling in the Charleston Harbor Watershed, South Carolina

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Charleston Harbor Project
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Submitted to:

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Charleston Harbor Project
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Submitted by:

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Abstract

This report details the development of a predictive model for archaeological site location in the Charleston Harbor watershed. The study was funded through the Charleston Harbor Project by the Office of Ocean and Coastal Resource Management, South Carolina Department of Health and Environmental Control, in conjunction with the National Oceanic and Atmospheric Administration (NOAA). The work was performed by New South Associates, Inc. of Stone Mountain, Georgia and Irmo, South Carolina between 1994 and 1996.

The study was carried out in two stages. The first consisted of a broad survey of archaeological site file data and reports, while the second involved the compilation and formal analyses of well controlled data bases. The predictive models derived from the second stage take the form of multiple regression equations that provide a basis for evaluating the potential site density of any single location within the larger project area. The models were tested using data from archaeological surveys not incorporated into the original model formulation. Overall, the models were demonstrated to be successful in differentiating areas of high, medium, and low archaeological site potential. They were also shown to have utility in predicting and estimating real site densities in unsurveyed tracts.

This study represents only an initial step in the construction of a sophisticated predictive model of site location in the Charleston Harbor watershed. Future studies should be able to build on this foundation to produce more accurate and specific models that will enhance our ability to manage and plan the development of the region in a reasoned and informed manner.

Acknowledgements

This study was completed with the help and assistance of a number of individuals that deserve special mention. First, I would like to extend thanks to the personnel of the Charleston Harbor Project, whose efforts and support made this project not only possible, but also successful. In particular the support of Hayward Robinson, Director, James Hackett, Environmental Planner, and Shirley Conner, Environmental Planner is appreciated and sincerely acknowledged. Other individuals that commented on and reviewed the technical aspects of the study are also acknowledged for their contributions. These include Bob Morgan of the United States Forest Service, David Anderson and John Tucker of the National Park Service, Nancy Brock, Lee Tippett, and Neils Taylor of the South Carolina Department of Archives and History, Paul Brockington and Eric Poplin of Brockington and Associates, Chris Amer, Keith Derting, and John Leader of the South Carolina Institute of Archaeology and Anthropology, and James Scurry of the South Carolina Water Resources Commission. A special note of gratitude is extended to George McDaniel, Executive Director of Drayton Hall, for his interest in the project and his willingness to make available to me the archaeological documentation of this beautiful plantation. I was unable to use the information in formulating the initial models presented here, but the data that has been collected at Drayton Hall will prove to be a valuable resource when more specific modelling the Colonial period of the Lowcountry is attempted in the future. Finally, I would like to thank the individuals who worked with me during the data collection phase of the project. These included Tony Greiner, Patty

Evans-Shumate, Darwin Ramsay-Styer, and Suzanne Rauton. A heartfelt debt of gratitude is extended to these individuals for their diligence and assistance in bringing this project to completion.

Table of Contents

Abstract... i

Acknowledgements................................... iii

Table of Contents.................................. v

List of Figures.................................... vii

List of Tables..................................... ix

I. Introduction.................................... 1

II.Environmental Overview.......................... 3
Regional Setting................................ 3
Geology... 3
Physiography.................................... 8
Climate... 10
Biogeography.................................... 11
Upland Ecosystems............................. 11
Swamp Ecosystems.............................. 16
Stream Ecosystems............................. 17
Maritime Ecosystems........................... 18
Saltmarsh Ecosystems.......................... 21
Estuaries and Bays............................ 22

III. Cultural and Historic Background (Cable and Reed) 23
Prehistory...................................... 23
Paleoindian and Early Archaic................. 24
Middle Archaic................................ 25
Late Archaic and Woodland..................... 26
Mississippian and Protohistoric............... 28
History... 34
Historic Contact.............................. 34

Colonial Period 36
Post-Revolutionary War........................ 40
Civil War and Later........................... 40

IV. Project Overview and Objectives....................... 43
Stage I Study.................................. 44
Sample Selection.............................. 45
Definition of Variables and Data Collection..... 46
Statistical Pattern Analysis.................. 48
Model Assessment.............................. 49
Stage II Study................................. 52
Expansion of Control Point Sample............... 52
Validation.................................... 55
Concluding Remarks............................. 55

V. Description and Measurement of Variables............... 57
Archaeological Variables....................... 57
Spatial Variable............................... 57
Soil Hydrology Variables...................... 63
SCS Soil Type................................. 67
Soil Interface Group.......................... 69
Soil Drainage Rank Diversity.................. 69
Stream Rank Distances......................... 70
Distance to Nearest Major Road................ 71
Archaeological Site Spatial Variables........... 71
Coverage Radius............................... 71

VI. Descriptive Analysis of the Samples................... 73
SCS Soil Type and Associated Drainage Rank........... 73
Soil Interface Distances....................... 75
Soil Interface Category and Type............... 79
Soil Drainage Diversity........................ 84
Distance to Streams............................ 93
Distance to Roads.............................. 94
Site Spatial Variables......................... 95
Concluding Remarks............................. 98

VII. Predictive Models.................................... 99
Fundamentals of Regression........................... 99
Correlational Analysis............................... 102
Multiple Regression Models........................... 112
Model Testing.. 121
Interior Tests................................... 128
Maritime Tests................................... 137
Limitations and Extensions of the Models............. 146
Concluding Remarks................................... 150

VIII. Review and Conclusions........................... 153
Regional Patterns.................................. 153
Overview of the Models............................. 157
Final Remarks...................................... 159

References
Cited.. 161

Appendix A -Listing of Stage I projects.................. 185
Appendix B -Frequency of Culture Historic Components for Stage
I Projects... 189
Appendix C -Interior Sample Data Base, Stage II.......... 193
Appendix D -Maritime Sample Data Base, Stage II.......... 223
Appendix E - Interior Test 1 Data Base................... 237
Appendix F - Interior Test 2 Data Base................... 243
Appendix G -Interior Test 3 Data Base.................... 251
Appendix H -Maritime Test 1 Data Base.................... 261
Appendix I - Maritime Test 2 Data Base................... 267
Appendix J - Site Density Data Base, Interior Tests...... 275
Appendix K -Site Density Data Base, Maritime Tests....... 281
Appendix L -Site Area Density Data for Projects in Berkeley
and Charleston Counties............................ 287

List of Figures

1. Sea Islands regional map.............................. 4
2. Pleistocene barrier island sequence on the South Carolina coast.. 6
3. 1770 parish divisions of the lowcountry............... 38
4. Map of stage I project locations...................... 47
5. Map of Pinckney Island soil drainage groups showing site location... 50
6. Map of Pinckney Island soil drainage groups showing sample grid layout.. 51
7. Map of stage II Interior Sample loci.................. 53
8. Map of stage II Maritime Sample loci.................. 54
9. Portion of Thornton-Morden Map of 1695................ 60
10. Portion of James Cook Map of 1773..................... 61
11. Portion of Smith (1988) compilation map of 18th century Cooper River plats..................................... 62
12. Method of distance measurement for soil interfaces.... 68
13. Histogram of soil drainage rank, Interior Sample...... 74
14. Histogram of soil drainage rank, Maritime Sample...... 77
15. Histogram of soil interface type (INT),Interior Sample 81
16. Histogram of soil interface type (INT),Maritime Sample 83
17. Histograms of diversity radii, Interior Sample........ 87
18. Histogram of mean soil diversity (Hx), Interior Sample 88
19. Histograms of diversity radii, Maritime Sample........ 91
20. Histogram of mean soil diversity (Hx), Maritime Sample 92
21. Distribution of the variable SITE.2, Interior Sample.. 96
22. Distribution of the variable SITE.2, Maritime Sample.. 97
23. Scatterplot of perfect regression.....................101
24. Progression of correlation coefficients (r) for coverage radii, Interior Sample................................109
25. Progression of correlation coefficients (r) for coverage radii, Maritime Sample................................110

26. Progression of adjusted R^2 values for coverage radii...113
27. Histograms of leverage values, Interior Sample...... 115
28. Histograms of leverage values, Maritime Sample...... 116
29. Scatterplots of correlations between LSITE.2P and LSITEdP for the best fit multiple regression equations...... 122
30. Project map of Interior Tests 1 and 2............... 123
31. Project map of Interior Test 3...................... 124
32. Project map of Maritime Test 1...................... 126
33. Project map of Maritime Test 2...................... 127
34. Distribution of LSITE.2P, Interior Test 1........... 129
35. Distribution of LSITEdP, Interior Test 1............ 130
36. Distribution of LSITE.2P, Interior Test 2........... 131
37 Distribution of LSITEdP, Interior Test 2............ 132
38. Distribution of LSITE.2P, Interior Test 3........... 133
39 Distribution of LSITEdP, Interior Test 3............ 134
40. Distribution of LSITE.2P, Maritime Test 1........... 140
41 Distribution of LSITEdP, Maritime Test 1............ 141
42 Distribution of LSITE.2P, Maritime Test 2........... 142

43 Distribution of LSITEdP, Maritime Test 2............ 143
44 Comparisons of predicted corrected and actual site means... 149
45. Site area densities by compartment, Francis Marion National Forest.................................... 156

List of Tables

1. Ordinal scale values assigned to the SCS soil drainage classification.. 64
2. Ordinal scale values of soil types in Berkeley County (Long 1974).. 65
3. Ordinal scale values for soil types in Charleston County (Miller 1971).. 66
4. Soil type representation for the Interior Sample...... 76
5. Comparison of soil drainage rank representation, Interior Sample... 76
6. Soil type representation for the Maritime Sample...... 78
7. Comparison of soil drainage rank representation, Maritime Sample... 78
8. Adjusted comparisons of soil drainage rank representations, Maritime Sample...................... 79
9. T-test comparisons for soil interface distances, Interior Sample... 79
10. T-test comparisons for soil interface distances, Maritime Sample... 80
11. Frequency summaries of soil interface category (CAT), Interior Sample.. 80
12. Frequency summaries of soil interface type (INT), Interior Sample.. 82
13. Frequency summaries of soil interface category (CAT), Maritime Sample.. 82
14. Frequency summaries of soil interface type (INT), Maritime Sample.. 84
15. Frequency and percentage summaries for H.05, H.10, H.20, and H.30,Interior Sample............................. 85
16. Frequency and percentage summaries for mean soil drainage rank diversity (Hx),Interior Sample.................. 86
17. Summary of Chi-square comparisons for soil drainage diversity, Interior Sample............................ 86

18. Frequency and percentage summaries for H.05, H.10, H.20, and H.30,Maritime Sample............................ 89
19. Frequency and percentage summaries for mean soil drainage rank diversity (Hx),Maritime Sample................. 90
20. Summary of Chi-square comparisons for soil drainage diversity, Maritime Sample.......................... 90
21. Summary statistics for distance to stream variables, Interior and Maritime Samples....................... 93
22. T-test comparisons of distance to stream variables for sites and control points, Interior and Maritime Samples.. 94
23. Frequency and percentage breakdowns for SITE.2, Interior Sample... 95
24. Frequency and percentage breakdowns for SITE.2, Maritime Sample... 98
25. Correlation (r) matrix of variables, Interior Sample 103
26. Spearman:s rank correlation (Rho) matrix of variables, Interior Sample................................... 105
27. Correlation (r) matrix of transformed Log10 variables, Interior Sample................................... 105
28. Correlation (r) matrix of variables, Maritime Sample. 106
29. Correlation (r) matrix of transformed Log10 variables, Maritime Sample.................................... 107
30. Progressions of correlations by coverage radius (CR) for LSITE.2 and environmental variables, Interior Sample. 108
31. Progressions of correlations by coverage radius (CR) for LSITEd and environmental variables, Interior Sample.. 108
32. Progressions of correlations by coverage radius (CR) for LSITE.2 and environmental variables, Maritime Sample. 111
33. Progressions of correlations by coverage radius (CR) for LSITEd and environmental variables, Maritime Sample.. 112
34. Multiple regression summary table of LSITE.2 on LSTd, LHx, LDR4, LDR1/2,and LNEAR, Interior Sample......... 117
35. Multiple regression summary table of LSITEd on LSTd, LHx, LDR4, LDR1/2,LNEAR, and LDR0, Interior Sample........ 118

36. Multiple regression summary table of LSITE.2 on LSTd, LHx, LH.05, LDR6,LDR1, and LDR0, Maritime Sample.......... 120
37. Multiple regression summary table of LSITEd on LSTd, LHx, LH.05, LDR6,LDR1, and LDR0, Maritime Sample.......... 120
38. Site density for LSITEdP by site occurrence isotherms, Interior tests.. 137
39. Site density for LSITE.2P by site occurrence isotherms, Interior tests.. 137
40. Proportional comparison of archaeological site area and area of site occurrence isotherms, Interior tests.... 138
41. Results of Chi-square comparisons of percentage of archaeological sites by percentage of site occurrence isotherm area, Interior tests........................ 138
42. Results of Chi-square comparisons of percentage of archaeological sites by percentage area of high and medium site occurrence isotherms only, Interior tests 138
43. Site frequency, site area, and respective densities by site occurrence isotherm, LSITEdP distribution, Maritime tests....................................... 144
44. Site frequency, site area, and respective densities by site occurrence isotherm,LSITE.2P distribution, Maritime tests... 144
45. Proportions of archaeological site frequency and site area densities by areas of site occurrence isotherm, Maritime tests....................................... 145
46. Results of Chi-square comparisons of proportions of archaeological site frequency and site area by proportion of site occurrence isotherm area, Maritime Sample.. 145
47. Results of Chi-square comparisons of proportions of archaeological site frequency and site area by proportion of area of high and medium site occurrence isotherms only....................................... 145
48. Correlations of predicted and actual site variables from test locations................................. 147

49. Summary statistics for predicted and actual site data, test localities.................................... 147
50. Paired t-Test comparisons for predicted and actual site data, test localities................................ 148
51. Summary statistics for actual and corrected predicted site occurrence variables, Interior tests........... 150
52. Site are data for grouped survey locations from modern surveys in Charleston and Berkeley counties......... 154

I. Introduction

This report will describe the various stages of research and development undertaken in the construction of a predictive model for archaeological site location in the greater Charleston Harbor watershed. The project was funded and administered through the South Carolina Department of Health and Environmental Control, Office of Ocean Coastal Resource Management, Charleston Harbor Project by a grant from the National Oceanic and Atmospheric Administration (NOAA) with support from the South Carolina Department of Archives and History. The objective of the Charleston Harbor Project is to provide local leaders with information needed to manage rapid growth and sustain the rich economic, cultural, and natural resources of Charleston. In keeping with these objectives, this study will provide a generalized overview of the most sensitive locations within the watershed for archaeological sites. An archaeological analysis of this scale and detail has never before been attempted in South Carolina; simply because this is not the usual manner in which research is conducted. Generally, archaeological investigation focuses on the excavation of a single site or the survey of a specific and limited sized tract of land. It is a rare opportunity to be afforded the time to sit back and consider the implications of our work at a broader, regional scale. As a consequence, this study will have utility for not only community leaders concerned with the planning and development of the watershed, but also for professional archaeologists and regulators entrusted with the task of efficiently managing and conserving the cultural resources of the State of South Carolina.

The report of findings is presented in seven chapters, including this introduction. The second and third chapters introduce and describe respectively the environment and the culture history of the Charleston Harbor region. Although not integral to the project these chapters are intended to provide the reader with an appreciation of the remarkable time depth and rich character of the archaeological and natural resources of the region. The fourth chapter provides an overview of the project and its objectives. The fifth chapter discusses and defines the archaeological and environmental variables used in generating the Charleston Harbor predictive model. The sixth chapter summarizes the data collected during the analysis stage and discusses the identified associational patterns of the variables. The seventh chapter describes the methodology and structure of the Charleston Harbor predictive model. The model is also empirically tested and evaluated in this chapter. The final chapter summarizes the findings of the report and considers some broader, regional patterning of site location. The last chapter is followed by a references cited section. Data files used in the development of the model are presented as appendices at the back of this report.

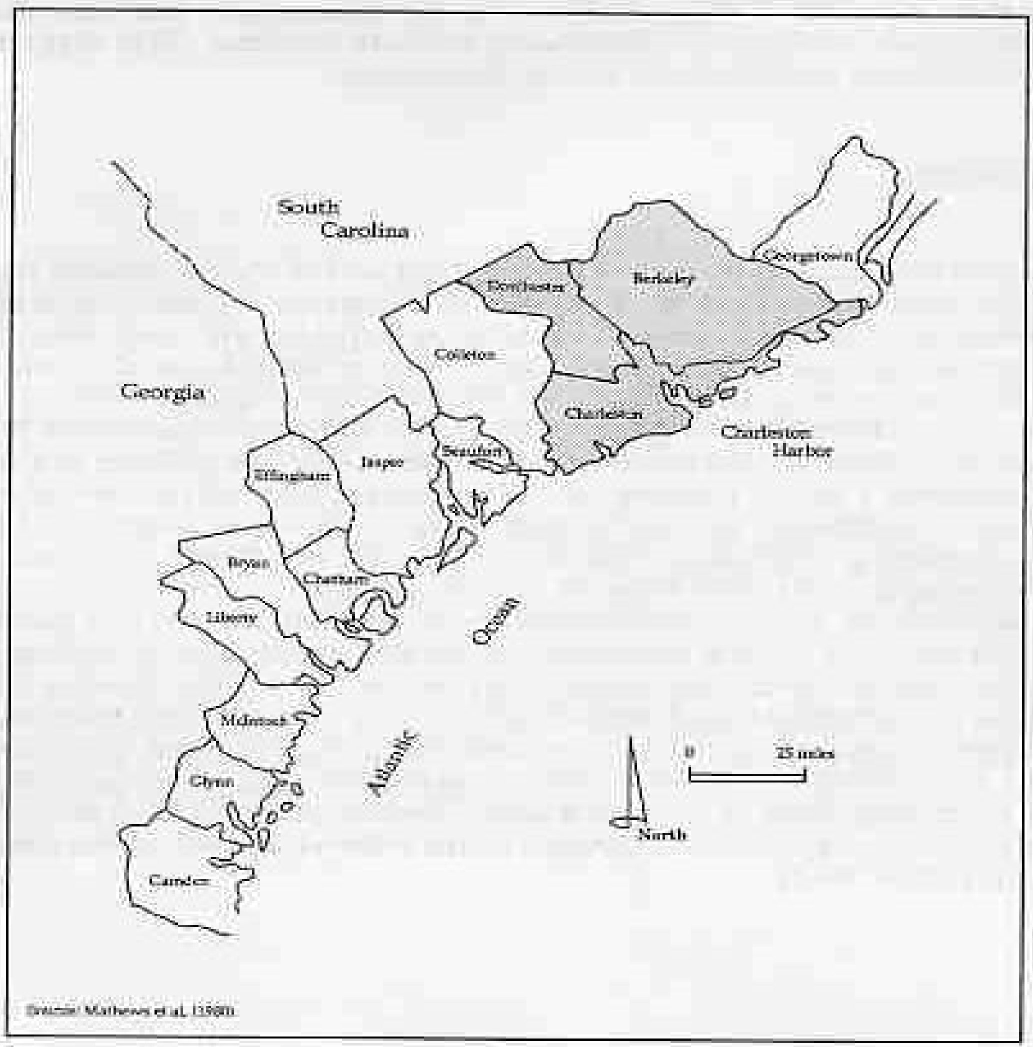
II. Environmental Overview

It is, on the one hand obvious, and on the other little appreciated, that the character of cultural development in any particular region of the world is strongly influenced by the natural setting. The greater Charleston Harbor area is an especially good example of this axiom due to the distinctively rich and diverse natural environment of the coastal lowcountry of South Carolina. This chapter will discuss the distinctive characteristics of this environment.

Regional Setting

Charleston Harbor is situated on the northern end of the Sea Islands Coastal Region of the South Atlantic Slope. Various studies have set the boundaries of this region differently to accommodate a diversity of purposes and objectives. The current treatment will follow the definition developed by Mathews et al. (1980:1) for the Coastal Ecosystems Project conducted by the South Carolina Wildlife and Marine Resources Department (Figure 1). By this definition the Sea Island Region extends over approximately 480 km of coastline from the St. Marys River in extreme southeastern Georgia to the northern end of Pawleys Island on the central South Carolina coast, and includes the coastal counties of Georgia and South Carolina as well as the bordering counties of Berkeley and Dorchester (South Carolina), and Effingham (Georgia). All definitions of the coastal region incorporate a certain degree of arbitrariness

Figure 1. Sea Islands regional map



when inland boundaries are considered, but this particular definition includes only a minor amount of inland area and as such is successful in isolating the region from the other environments of the Coastal Plain. Archeological investigations and ethnohistorical accounts indicate that the Sea Islands Region supported a series of interrelated prehistoric and protohistoric populations that shared a distinctive cultural expression and a unique maritime economy. Examining some of the broad environmental parameters of this region, then, should provide a better understanding of the cultural, as well as the physical, context of the current study.

Geology

Three major structural units underlie the Sea Islands: 1) the Peninsular Arch-Central Georgia Uplift, 2) the Southeast Georgia Embayment, and 3) the Cape Fear Arch (Herrick and Vorhis 1963). The former represents the major positive tectonic feature in the Southeastern United States and extends from southeastern Georgia into Florida. Nearly 1200 m of Mesozoic and Tertiary sedimentary rock formations overlie the crest of this unit. The Southeast Georgia Embayment is a depression underlying most of the Georgia sea islands and supports a 1500 m stratigraphic sequence of sedimentary rocks of Mesozoic and Tertiary age. The Cape Fear Arch covers most of the North Carolina and South Carolina coasts and is described as an asymmetrical uplift. Overlying deposits of Mesozoic and Cenozoic sedimentary rocks are much shallower here, extending to a depth of only 470 m at the crest of the

Figure 2. Pleistocene barrier island sequence on the South Carolina coast

uplift near the South Carolina-North Carolina border. The Cape Fear Arch is not tectonically active today, but Winker and Howard (1977) indicate periods of activity during the Tertiary and early Quaternary.

Mesozoic and Tertiary rocks underlying the South Carolina coast are organized into a sequence of sedimentary formations which are overlain by more recent Pleistocene sediments (Colquhoun 1974; Cooke 1936, 1943; Dubar et al. 1974). The earliest rocks in this sequence are the Cretaceous sandstones, siltstones, and shales which rest unconformably on eroded metamorphic crystalline basement rock. Above this is a thick sequence of limestone formations (i.e. Cape Fear, Middendorf, Black Creek, Pee Dee, Black Mingo, Santee, Cooper, and Duplin formations) that grade to more clastic-rich deposits in the Miocene and Pliocene layers. The younger Pleistocene sediments consist of a sequence of horizontally stratified formations and geomorphic units arranged as a series of terraces extending inland approximately 100 km to the Orangeburg Scarp. The edge of each terrace consists of a discontinuous sand ridge that represents the remains of an earlier barrier island chain, while the clayey sand plain behind each was once back-barrier tidal flat lagoons and marshes (Colquhoun 1969).

Winker and Howard (1977) have grouped the numerous terrace units into a series of three beach ridge-barrier island sequences that span the entire length of the outer Coastal Plain of Georgia and South Carolina (Figure 2). Problems exist in correlating this sequence with earlier mapping units and nomenclature in South Carolina (Colquhoun 1974; Dubar et al. 1974), but Mathews et al. (1980) have proposed a workable solution. The most inland of the sequences is referred to as the Trail Ridge-Orangeburg Scarp. This is a rather dramatic and continuous geomorphic unit that demarcates the boundary between the rolling topography of the Inner Coastal Plain and the flat, terraced terrain of the Outer Coastal Plain (Kovacik and Winberry 1987:20). The Pliocene-aged Okefenokee / Sunderland / Coharie cyclic unit (Marietta Formation) lies between this sequence and the Surrey Scarp (Colquhoun 1974), which demarcates the western margin of the intermediate Effingham sequence of terraces. The Effingham sequence is characterized by a series of discontinuous ridges that extend laterally over a wide region roughly corresponding to the early Pleistocene Wicomico/Waccamaw Formation. A group of closely related scarp features designated the Summerville Scarps (Wicomico and Phenholoway barrier island facies) mark the eastward boundary of the Effingham sequence. The Talbot-Pamlico cyclic unit is bounded by the Summerville and Awendaw (Talbot and Pamlico barrier island facies) scarps, the latter of which demarcate the western edge of the youngest ridge sequence (Chatham). The Chatham sequence is characterized by numerous fragmented ridge series and very discontinuous scarps. The Georgia coast contains the full complement of mapped formations belonging to this sequence, but the latest complexes (i.e. the Princess Anne and Silver Bluff) are missing or submerged on the South Carolina coast.

Because of their elevated topographical positions, the linear ridges formed by the various barrier island facies on the Outer Coastal Plain played significant roles in site locational patterning throughout prehistory. Not surprisingly, they also appear to have served as a major determinant of historic settlement. Both transportation arteries and settlements are situated on these well drained ridges in the Charleston Harbor area. For instance, the Pamlico facies supports US 17, the City of Charleston and the towns of McClellanville, Awendaw, and Wando-Cainhoy; the Talbot facies, which is split into two parallel segments, contains SC 41 and the communities of Honey Hill, Huger, Jamestown, and Bethera; while US 52 and the towns of Alvin, St. Stephens, Bonneau, McBeth, and Moncks Corner rest on the Phenholoway facies.

Other Pleistocene-age deposits occurring in the Sea Island Coastal Region include fluvial features such as floodplains, point bars, dune sheets, terraces and Carolina Bays. A typical feature of the major river valleys is the dune sheet formations which have been dated to the Late Wisconsin Glaciation (20,000 to 10,000 years B.P.). These features exhibit a parabolic structure and generally occur as a series of southwest-northeast trending ridges located on the eastern edges of river valleys, suggesting to Thom (1970) that they represent degraded parabolic dunes formed by prevailing westerlies during a period of reduced discharge and geomorphological transition from a braided to a meandering river channel. The outer Coastal Plain segments of the Pee Dee (Thom 1967), Santee (Colquhoun 1972), Savannah, and Altamaha Rivers all possess this peculiar structure (Mathews et al. 1980). The dune fields typically overlie Pleistocene terrace and floodplain formations in these river valleys. Carolina Bays are shallow, elliptical depressions ranging between approximately 1 and 4 km in length (Kaczorowski 1977;

Thom 1970). They tend to be oriented in a northwest-southeast direction and the sand rims that form around their edges tend to be best developed on their southeastern edges. The manner in which these features formed has been a topic of controversy for some time, but the explanation provided by Thom (1970) is currently the favored position. He argues that these features represent relictual ponds that were transformed into the characteristic shape of the Carolina Bay through wave action controlled by prevailing southwesterly winds, accompanied by cool, pluvial conditions during the middle to late Wisconsin.

Holocene-age (the last 10,000 years B. P.) sedimentation and landform development has contributed significantly to the physiographic structure of the modern coastline. Holocene features include the river bottoms, swamps, marshes, beaches, modern dune ridges, tidal flats, tidal deltas, biogenic reefs, estuarine bottoms, and the near shore shelf. The soils of the sea islands and the immediately adjacent mainland are formed on Pleistocene deposits (Hoyt 1968). Mainland soils are the most mature and generally exhibit distinctive horizon development. These soils are sandy to loamy in texture and are moderately to highly acidic (Miller 1971). Seasonal water-logging typifies conditions on the Princess Anne Formation and the Silver Bluff cyclic unit except for ridge elevations where drainage is better. The Pleistocene soils of the sea islands are less diverse and horizon development is less distinct than is typical of the mainland (Johnson et al. 1974; Mathews et al. 1980). Nevertheless, they are structurally very similar, consisting of highly acidic sands overlying sandy to loamy substrate. Organic staining occurs where soils are saturated for significant periods, but otherwise organic content is slight. The seaward fringes of the sea islands are composed of younger Holocene sand deposits with very indistinct horizon development. Although some islands classified as barrier islands are Pleistocene in age, most are built up from Holocene sands. Tidal marsh bottoms consist of fine sands, clays, and organic deposits of Holocene age overlying older Pleistocene sands. These sediments contain high concentrations of iron sulfides and reduced organic compounds and are generally neutral to slightly basic.

Physiography

Late Tertiary sea level transgressions and barrier-island formation processes have combined to create the distinctive physiography typical of the modern Sea Island Coastal Region (Mathews et al. 1980). The mainland is comprised of three major barrier island-beach ridge sequences that, when viewed on the landscape, appear as a series of broad, depositional terraces running subparallel to the coastline. These features represent buried Pleistocene coastal features (i.e. barrier islands, spits, marshes, and lagoons) as we have already discussed. Immediately seaward of the mainland are salt marshes and estuaries where fresh water discharge is sufficient to promote this special type of ecosystem. Estuaries are found in two different environments: (1) within the submerged mouths of major rivers, and (2) behind barrier islands in areas away from major freshwater discharge. Beyond these submerged features are the complex chain of low-lying islands which form the ocean-ward edge of the region.

Three types of coastal islands are recognized: (1) sea islands which are partially submerged Pleistocene-aged mainland, (2) barrier islands of Holocene age, and (3) marsh islands also of Holocene age (Mathews et al. 1980:61). The sea islands are generally situated landward from the younger barrier islands, but there are numerous instances where all or significant portions of sea islands are directly exposed to open ocean, and in these instances an ocean-ward fringe of Holocene dune ridges overlie Pleistocene sediments. Sea islands are generally subrectangular in shape, vary between 1 and 18 km in length, are oriented parallel to the shoreline, and are surrounded by salt marsh and sometimes brackish or freshwater marsh. Maximum elevations range between 1.5 and 10.5 m AMSL and the topography typically alternates between broad, poorly defined ridges and swales that run parallel to the orientation of the island. Barrier islands are aligned parallel or subparallel with the shoreline and again exhibit a ridge-swale topography (Colquhoun and Pierce 1971). These ridges, however, may be relatively steep and can attain maximum elevations of as much as 16.5 m AMSL. The barrier islands generally separate salt marsh lagoons from the open ocean. Bird keys and banks are the smallest subtype of barrier island and consist of emergent spits or sand bars located at tidal inlets and in broad bays (Hayes et al. 1975). These islands are seasonally submergent and are characterized by low relief. Marsh islands are defined by tidal creek channels and are composed of widely spaced Holocene sand ridges surrounded by salt marsh. Generally, marsh islands are located in the filled lagoons behind barrier islands, but occasionally they front the ocean where barrier islands have been removed through erosion.

The major rivers of the coastal plain exhibit mature stream morphologies consisting of narrow, meandering channels, broad floodplains containing ox-bows, meander scrolls and natural levies, and dune fields. Small, convex deltas have formed at the mouths of these rivers, but sedimentation is not laterally extensive in spite of significant bed load and low energy wave action (Mathews et al. 1980:76). The Pee Dee delta empties into Winyah Bay, which represents a submerged Pleistocene estuary (Thom 1970). The Santee, Savannah, and Altamaha rivers dump their loads directly into the Atlantic Ocean, but their deltas are typically underdeveloped and resemble drowned valleys rather than broad, fan-like depositional centers prograding out onto the near shore shelf. The extensive coastal marshlands of the Cape Romain region may represent an earlier Holocene delta of the Santee River that formed prior to 4500 B. P. (Aburawi 1972; Woollen 1976). Similar broad expanses of what may be relict deltas occur south of the mouth of the Savannah River and adjacent to the Cooper River at Charleston (Mathews et al. 1980:76). The intertidal portions of the river mouths grade from salt, to brackish, to fresh water in an upstream sequence. The current distribution of tidal marshes appears to have been established in the last 5,000 years (Colquhoun et al. 1980).

Estuaries have been defined as semi-enclosed bodies of water that have a free connection with the open sea and to fresh water sources of sufficient magnitude to significantly dilute marine salt water (Pritchard 1967). Three types of estuaries are recognized (Mathews et al. 1980:80). The drowned river valley type occurs at the mouths of major streams such as Charleston Harbor or the mouth of the Santee. The second type is of bar-built morphology and is formed when migrating barrier islands separate near shore marsh from the open ocean. Murrells Inlet, Cumberland Sound, and Bulls Bay constitute examples of bar-built estuaries. The third type represents a combination of the other two. Winyah Bay, Sapelo Sound, and St. Andrews Sound are examples of this drowned valley-barrier island type.

Estuarine sediments primarily derive from riverine bed load, but lateral movement of sediments along shoreline beaches and offshore redeposition also contribute to the overall matrix of clays and sands. Most of the marsh-covered near shore plains represent sediment-filled Pleistocene estuaries. Two types of water circulation patterns characterize the estuaries of the Sea Island Coastal Region: (1) two layer flow, and (2) vertically homogeneous flow. Two layer flow occurs in drowned valleys where freshwater discharge is significant, such as Charleston Harbor, Winyah Bay, and the mouths of the Savannah and Santee rivers. Vertically homogeneous flow occurs where freshwater discharge is minimal and includes such locations as Bulls Bay, Port Royal Sound, Wasaw Sound, and Sapelo Sound.

Climate

The climate of the Sea Island Coastal Region has been described as "humid subtropical" (Critchfield 1974), typified by short, mild winters and hot, humid summers. Temperatures on the coast are moderated by the ocean and as a consequence maximums are lower and minimums are higher than inland locations. Moreover, the growing season is longer, grading from approximately 225 days in the Piedmont to nearly 300 days on the coast (Carter 1974). On the South Carolina coast, average July temperatures reach 27.2° C while average January temperatures range between 8.8° C and 10° C (Kovacik and Winberry 1987). Summers are dominated by warm, moist, tropical air masses, and precipitation during this season is generally produced by convection storms. Winter precipitation, by contrast, originates from continental fronts out of the north and west. Spring usually represents the driest season, but rare drought conditions usually occur in the fall. The South Carolina sea islands and dune strand receive an average of 1240 mm of precipitation annually, while the Outer Coastal Plain averages 1320 mm.

Tropical cyclones of hurricane force are a common feature of the Sea Islands (Purvis 1980). Storms of this kind are characterized by counter-clockwise wind rotation and originate in the North Atlantic subtropical convergence zone east of the West Indies. The storm tides associated with hurricanes typically raise mean sea level 2 to 6 meters above normal and can result in extensive inland flooding (Myers 1975; Purvis and Landers 1973). Peak hurricane season occurs in late summer and early fall, but the seasonally earliest one to strike the South Carolina coast occurred in May. The coast of South Carolina tends to be affected more by hurricane force winds than the Georgia coast, and Purvis and Landers (1973) estimate that 169 hurricanes have struck South Carolina between 1686 and 1972. Rainfall associated with hurricanes contributes about 15 percent of the annual precipitation along the coast and can result in enormous quantities of rain within a period of only several days.

Biogeography

Owing to its transitional stage of emergent coastline development (see Strahler 1977), the Sea Islands region supports one of the most complex coastal ecotones in the world. Six distinctive ecosystems exist side-by-side as a series of broken belts or zones closely corresponding to the physiographic structure of the region (Sandifer et al. 1980). The two natural ecosystems of the mainland consist of upland forest communities generally assignable to oak-pine (Braun

1950) and loblolly-shortleaf pine associations, and swamp communities in the poorer drained locations. In general, the upland communities are concentrated on the barrier island facies of the inland terrace complexes, while the swamp communities occur most heavily on the back barrier lagoon facies and along river bottoms. Freshwater stream environments constitute a third ecosystem. A fourth ecosystem, identified as the Maritime Forest, occupies the islands and the coastal fringe or strand of the mainland. Maritime communities are distinctively zoned and consist of three subsystems including, in successional order, beach dunes, transitional shrub thickets, and maritime forest. Live oak, magnolia, red bay, loblolly pine, wax myrtle, and palmetto comprise the principle dominants and subdominants of the maritime forest. Finally, coastal wetland ecosystems include the shallow marshes of the near shore shelf and the deeper estuaries positioned at inlets between the marshes and the landward side of the barrier islands. Some of the more salient features of each of these ecosystems will be described further below.

Upland Ecosystems

The Outer Coastal Plain of the Atlantic and Gulf coasts has been characterized as a "food-poor" pine barrens environment, dominated by long-leaf pine forest with very low species diversity (Larson 1980; Milanich 1971). Reconstructing pre-European forest communities, however, is a difficult task due to the great successional impacts of historic (and also prehistoric) landuse and, consequently, much controversy exists concerning the composition and distribution of "pristine" climax vegetation in the

Southeastern United States (Delcourt and Delcourt 1977, 1987; Quarterman and Keever 1962; Shelford 1963). Quarterman and Keever (1962) have argued that the current loblolly-shortleaf pine dominated forests of the Coastal Plain are the product of modern forestry management practices and other types of historic landuse, and that these forests are replaced by a Southern mixed hardwood climax when allowed to mature. Nevertheless, given the abundance of sub-climax soil conditions (e.g. saturation), it is probable that natural forest distributions would have resembled a mosaic of mixed hardwood and pine dominated associations prior to the major period of European land development in the nineteenth century (Brooks and Canouts 1984:10-13; Widmer 1976:9). More recently, palynalogists have reconstructed a clear record of pine dominated communities on the Gulf and Atlantic coastal plains by at least 5,000 years ago and probably earlier (Delcourt and Delcourt 1987).

William Bartram's description of the Outer Coastal Plain along the Savannah River in the late eighteenth century conforms well with this reconstruction (Harper 1958:19-20). He described the region from the sea to approximately 50 miles inland as a level plain of loose sandy soil supporting mixed pine and oak forests. Sub-climax conditions have also been fostered by natural and human-induced forest fires which tend to interrupt normal successional processes. Ethnohistoric accounts indicate that a popular form of surround hunting employed by Southeastern aboriginal groups involved the use of fire lines of several miles in extent that were set in the dried detritus of the forest floor (see accounts by Bartram, Calderon, DuPratz, Lawson, and Smith in Swanton 1946:319-320). The Sewee Indians, who historically inhabited the vicinity of Charleston Harbor, apparently fired the cane breaks adjacent to swamps to drive and entrap game (Lawson in Lefler 1967:17). Such a practice would have regularly removed the young seedlings of climax species, preventing them from maturing at a normal rate. In combination with other land modification involving the clearing of forest for settlements and agricultural fields, aboriginal land-use practices not only perpetuated sub-climax forests, but also created pine savannas (i.e. parklands). In the early 1700s Lawson (Lefler 1967:23, 31, 34-35, 51, 59, 70) noted that in the Carolinas these savannas generally occurred in the vicinity of Indian villages along the rivers, and could extend for many acres. Similar observations were made during the earlier DeSoto and Pardo expeditions as well (see DePratter 1987; Larson 1980), and it is likely that this particular human-induced pattern of sub-climax patches can be extended far back into prehistory.

Widmer's (1976) reconstruction for the area around Lake Moultrie between the Cooper and Santee rivers serves as a useful basis for modelling the pre-settlement (pre-European) vegetation of the interior uplands of the Sea Islands. He identified three "pristine" subsystems, including the longleaf pine forest, the southern mixed hardwood forest, and pine savannas. The latter two, as discussed above, represent subclimax communities owing their existence to both natural and cultural causes, while the former constituted the mature climax vegetation of pre-settlement times. Upland communities were primarily restricted to the barrier island facies in the Outer Coastal Plain where soils were drier. Pine-savannas, however, were a specialized community associated with aboriginal swidden or field-rotation agriculture and were primarily confined to well drained bottomland and stream terraces. In coastal areas away from major rivers, however, native agricultural strategies may have been focused on the small levees of creeks or on the better drained ridges in locations sufficiently protected from salt spray and salt water immersion (see Crook 1986).

The mixed hardwood subsystem is composed of five basic community types in the region today (Sandifer et al. 1980:447): 1) mesic slope hardwoods, 2) upland mesic hardwoods, 3) hammocks, 4) scrub forest, and 5) dwarfed oak-mixed hardwoods. Scrub forest and hammocks occur primarily in Florida and southern Georgia and only rarely extend into South Carolina, while the dwarfed oak-mixed hardwoods community is a product of modern selective timber cutting in pine forests. The other communities, however, appear to approximate the normal range of variability associated with the mixed hardwood subsystem on the Outer Coastal Plain of South Carolina. The structure and composition of the mesic slope hardwood communities correspond closely with Braun's (1950) mixed mesophytic forest type. In the lowlands of the Southeast such communities typically occur on dissected riverbluffs, ravines and high bottomland where edaphic conditions are moist but well drained. This community has also been referred to as "beech ravine" (Kohlsaat 1974), "ravine slope" (Hartshorn 1972), or "bluff and slope forest" (Wharton 1978) in more locally-based studies. Dominants in the South Carolina mesic slope hardwoods communities consist of beech, bull bay, laurel oak, red maple, black gum, tulip tree, sweet gum, and loblolly pine. The upland mesic hardwoods community corresponds to Braun's (1950) "oak-hickory forest" type and represents the climatic climax vegetation of the Outer Coastal Plain according to Quarterman and Keever (1962). Dominants of this community, which tends to occupy the majority of the area on ridge tops, consist of beech, laurel oak, bull bay, white oak, sweet gum, mockernut hickory, water oak, southern red oak, pignut hickory, and black gum.

The long-leaf pine subsystem occurs in xeric, well-drained, sandy locations and in more mesic situations where fire has interrupted successional processes. (Sandifer et al. 1980:439). Fire-maintained stands of long-leaf pine may contain only a two-tiered structure including a canopy of predominantly long-leaf pine and a limited herbaceous layer composed of such commonly abundant species as ported nut rush, camphorweed, beggar ticks, panic grass, broom-straw, bracken fern, aster, goat's rue, and thoroughwort. In the successional phase of development, however, these forests are generally three-tiered, containing in addition a tall shrub layer. The saw palmetto is a dominant of this shrub layer in Georgia localities, but occurs only rarely in South Carolina. Other dominants common to both areas include immature pines and hardwoods, bitter gallberry, running oak, stagger bush, blueberry, and huckleberry. The successional type eventually develops into mixed pine and pine-mixed hardwood communities. In these communities long-leaf pine is often replaced by slash, loblolly, and short-leaf pine species. These successional types were not as common in prehistoric times, but the intensity of land modification was probably sufficient to perpetuate these associations in one form or another in restricted patches.

Unfortunately, very little is known about the pine-savanna subsystem. Lawson (Lefler 1967:34) provides a description of one large patch of savanna adjacent to a Congaree settlement in 1701:

> *... about Noon, we pass'd by several fair Savanna's, very rich and dry; seeing great Copses of many Acres that bore nothing but Bushes, about the bigness of Box-trees; which (in the Season) afford great Quantities of small Black-berrys.... Hard by the Savanna's we found the Town.... The Town consists*

> *not of above a dozen Houses, they having other stragling Plantations up and down the Country, and are seated upon a small Branch of Santee River. Their Place hath curious dry Marshes, and Savanna's adjoining to it, and would prove an exceeding thriving Range for Cattle, and Hogs....*

Lawson's use of the term *plantations* conveys the impression that much of the river valley margin of each of the tribes he described was punctuated with these clearings or savannas and that some patches were planted while the majority were unattended. The distribution of the Santee plantations, for instance, was described by Lawson as *lying scattering here and there, for a great many Miles* (Lefler 1967:24-25). The presence of bushes and briers on the Congaree savannas, moreover, suggests that the abandoned fields may have been maintained within a fallow rotation, as the early successional stage evinced by this scrub vegetation would have been replaced by immature pines and hardwoods within 5-20 years after abandonment of the field (Odum 1971:261). Undoubtedly, other successional stages of pine forest were also present along these river bottoms and terraces, reflecting yet earlier concentrations of aboriginal farming communities.

Odum's (1960) study of "old field" succession is probably a useful analog with which to model these bottomland savannas. In the initial stage of succession the open field is colonized by forbes and grasses over a period of two years. By the third year, sedges and shrubs begin to dominate and over a period of three to 20 years shrubs and immature trees replace the grasses and forbes. Young pine forests are established after about 25 years, and between about 75 and 100 years the mature pine forest is replaced by hardwoods under optimal climax conditions.

The pine-mixed hardwood and mixed hardwood communities contain the greatest abundance and diversity of terrestrial faunal species of the upland ecosystem communities. This has been detailed most for avian species (see Johnston and Odum 1956), but it also holds true for all other classes as well. At the base of the faunal food chain is a class of animals, including nematodes, arthropods, and myriapods, that spend all or portions of their lives within the soil matrix of the forest (Kevan 1968). Some of the more prevalent species of soil fauna in the region are nematodes, mites, springtails, and earthworms. A diverse assemblage of insects are present in these forests. Some of the more common species include mosquitoes, flies, midges, wasps, bees, sawflies, grasshoppers, butterflies, moths, termites, dragonflies, mantids, crickets, cockroaches, katydids, cicadas, trips, aphids, and pine beetles (Sandifer et al. 1980:453-455).

Amphibians and reptiles generally occupy moist habitats within the uplands such as leaf-litter, burrows, and temporary pools, and feed on soil fauna and insects. Numerous salamanders, hylid frogs or treefrogs, and toads dominate the amphibious fauna, while a wide array of lizards and snakes comprise the majority of the reptile species. Turtles are rare in the upland ecosystem, and are generally represented by only the eastern box turtle in South Carolina. The most common lizards include the green anole, ground skink, six-lined racerunner, and the eastern five-lined skink. A group of small snakes occupy the leaflitter habitat. The eastern scarlet snake, mole kingsnake, brown snake, northern redbelly snake, southeastern crown snake, eastern coral snake, pine woods snake, and the scarlet kingsnake tend to occur in this habitat in pine dominated communities. A number of larger snakes are less specific to habitat and include the southern black racer, corn snake, yellow rat snake, eastern hognose snake, southern hognose snake, eastern kingsnake, eastern coachwhip, and the eastern garter snake. Vipers tend to inhabit hardwood communities and the more common species of viper in the South Carolina Coastal Plain include the southern copperhead, cottonmouth water moccasin, pigmy rattle snake, and canebrake rattle snake.

Avian species tend to occupy very specialized niches in the forest and as such their habitat and forest associations tend to be better defined than species of the other faunal groups. Pine forests exhibit the lowest bird densities and species diversity. Only thirteen dominant species are listed for this forest type by Sandifer et al. (1980:465) including one large predator, the screech owl, and a series of primarily insectivorous birds including the red-bellied woodpecker, eastern wood pewee, southern crested flycatcher, the Carolina chickadee, the brown-headed nuthatch, the eastern bluebird, two warblers, summer tanager, and Bachman's sparrow. The ground-feeding bobwhite and the common crow complete the list of dominants. Vultures, several species of hawk, numerous additional insectivores including the endangered red cockaded woodpecker, and turkey comprise minor components of the avian assemblage. Thirty-two avian species are considered dominant in upland pine-mixed hardwood and mixed hardwood communities (Sandifer et al. 1980:469-470). The overall structure of this list, however, is very similar to the one produced for the pine communities. The screech owl is the single large avian predator of the mixed hardwood communities. Insectivores are the most abundant avian species here. Three species of woodpecker (i.e. pileated, red-bellied, and downy), the blue jay, the mourning dove, the Carolina chickadee, the Carolina Wren, the common crow, the hermit thrush, the tufted titmouse, the robin, the catbird, the blue-gray gnatcatcher, the cardinal, and various species of vireos, warblers, and sparrows comprise the list of dominants. Numerous additional moderately important and minor species are also listed including various hawks, vultures, owls, insectivores, and the turkey.

Dominant mammalian herbivores of the Upland forests of the Coastal Plain consist of white-tailed deer, squirrels, the eastern wood rat, and the cotton mouse. The opossum and raccoon comprise the dominant omnivores, while major carnivores include the gray and red fox, the striped skunk, the short-tailed shrew, the long-tailed weasel, the bobcat, and the black bear (Sandifer et al. 1980:472-478). Pre-settlement assemblages also included cougar, gray wolf, and possibly minor numbers of elk and bison (Penny 1950). Mammalian species generally do not have specialized niches and they can range over very large areas or territories.

Very few species would have occupied the pine-savanna patches on a permanent basis, but such communities would have provided an important "edge"-type feeding source for mammalian herbivores and omnivores, and predatory avian and reptilian species hunting for rodents and lagomorphs (Odum 1960). The primary mammalian dominants of old field communities in the region today consist of the eastern cottontail, cotton rat, eastern mole, least shrew, and the striped skunk (Sandifer et al. 1980:472-473). The marsh rabbit also extends its range into such locations when feeding pressures increase in the swamps. The white-tailed deer, raccoon, and opossum are nocturnal visitors to such patches to feed, and are generally accompanied by most of the major mammalian predators of the upland forest. Due to a lack of standing water and other moist environments, amphibians rarely occupy old fields, but numerous of the larger forest snakes (i.e. corn snake, yellow rat snake, southern black racer, eastern kingsnake, hognoses, eastern garter, and the eastern diamond back rattle snake) spend significant amounts of time in these patches to feed on rodents. In the earliest stages of succession the grasshopper sparrow and the meadowlark dominate the avian fauna, but over time numerous other species begin to inhabit these old field patches as well, including the Carolina wren, the mockingbird, the mourning dove, the bobwhite, the common crow, the sparrow hawk, and the red-tailed hawk.

Swamp Ecosystems

Swamp ecosystems are located on major river floodplains and creek bottoms, and in the vast reaches of the low-lying back barrier-lagoon facies of the terrace complexes where the water table is at or slightly above the ground surface. In the late eighteenth century William Bartram (Harper 1958:19-20) estimated that swamp lands comprised approximately one-third of the Outer Coastal Plain. Plant communities consist of hardwood forest associations dominated by hydric cypress, tupelo and gum species (Shelford 1963). Loblolly pine, shortleaf pine, water oak, white oak, and hickories occur on better drained topographic features. A series of species that Bartram (Harper 1958:20-21) specifically listed in association with the Savannah River swamps included red maple, water tupelo, bald cypress, hackberry, beech, azalea, and magnolia.

With several important exceptions, the faunal assemblage of the swamp ecosystem is the same as that described for the uplands. A major point of difference, however, is that floodplain and swamp populations tend to be much more dense owing to the greater productivity of the mesic-to-hydric environment (Shelford 1963:86-119). Moore (1967), for instance, estimated that carrying capacity for white-tailed deer was on the order of three to four times greater in a bottomland environment in South Carolina than it was in the adjacent uplands. The ranges of some species, of course, like the black bear, otter, beaver, marsh rabbit, muskrat and cougar, were more exclusively tied to the bottomlands (Langley and Marter 1973:157). Seasonal fluctuations in the population distributions of some species are also an important consideration in contrasting the uplands and swamps. For instance, both white-tailed deer and turkey aggregate in the uplands during the fall to feed on acorn mast (Lay 1969:9; Runquist 1979:275).

Stream Ecosystems

The streams of the Sea Islands are distributed within eight major drainage basins: 1) Pee Dee, 2) Santee-Cooper, 3) Edisto-Combahee-Salkehatchie, 4) Savannah, 5) Ogeechee, 6) Altamaha, 7) Satilla, and 8) St. Marys. These basins originate in either the Piedmont or near the fall line. Annual discharge for the highest ranking rivers; the Pee Dee, Santee-Cooper, Savannah, and Altamaha, ranges between 343 and 442 m^3/second, while the others range between 19 and 79 m^3/second (Mathews et al. 1980:79). In addition to these larger basins, the Coastal Plain also contains numerous tidal creeks that follow poorly defined drainage ways principally determined by the microtopography of the barrier island facies of the terrace complexes.

Streams of the Atlantic slope are characterized by the greatest annual productivity of any physiographic region in the United States (Rostlund 1952). Molluskan and piscine fauna constitute the bulk of the biomass in this ecosystem, which is ultimately maintained by algae and animal microorganisms. A significant drop-off occurs between biomass densities in the largest streams and those in tributaries and small creeks (Taylor and Smith 1978:47-48). For instance, the average biomass density of the Savannah River is 73.35 kg/acre, while the densities of its tributary creeks range between 6.80 and 42.25 kg/acre. This is, in part, a function of indigenous differences in productivity in stream sizes and in part the consequence of concentrated use of the largest streams by anadromous fish during the spring spawning season.

Dominant freshwater fish species in South Carolina streams include the longnose gar, bowfin, brook trout, redfin pickerel, chubs, shiners, dace, suckers, bullheads, channel catfish, sunfish, bluegill, warmouth, crappie, and largemouth bass (Loyacano 1975). Anadromous fish include the Atlantic sturgeon, American shad, gizzard shad, Threadfin shad, striped bass, and striped mullet. Freshwater molluskan fauna include gastropods and bivalves or mussels. Common bivalve species include river mucket, fat mucket, ***Quadrula*** species, rainbow shell, elk toe, deer toe, and floaters (Coker et al. 1921; Purchon 1968). Freshwater turtles and a wide variety of snakes, lizards, and salamanders similar to the list described for the upland and swamp ecosystems also inhabit the streams of the region. Aquatic mammals such as otter and muskrat are also numerous. A lush assemblage of aquatic and semiaquatic plants occur at, or slightly below, bank level, including cattail, duck potato species, bulrush, wild rice, American lotus, sedge, tuckahoe, golden club, and water parsnip (McPherson and McPherson 1977).

Maritime Ecosystems

The geographic limits of the maritime ecosystem have been defined in various different ways. Sandifer et al. (1980:108) include only the barrier islands in their discussion. However, a similar live oak-mixed hardwood forest occurs along the fringe of the mainland in the Sea Islands Coastal Region and Rayner (1974) and Wharton (1978) have argued that this strand should be viewed as an upland sere of the maritime forest. Although there are important differences between the mainland and barrier island forests, there are also important similarities which tend to distinguish the upland sere from the more inland ecosystems, and which also make it appropriate to discuss this sere within the general framework of the maritime ecosystem.

The inland sere, which has also been referred to as the live oak strand (see Milanich 1971:108), is considered a climax vegetation type for the narrow band of mainland fringe bordering the salt marsh and the Pleistocene sea islands. Its existence on the mainland is largely the result of salt spray and immersion which limits less salt-tolerant terrestrial arboreals (Oosting 1954), and its distribution rarely extends more than one mile inland. In South Carolina these forests are dominated by live oak, water oak, hickories, and loblolly pine (Gaddy 1977). Subdominant species include American holly, red bay, and bull bay (magnolia).

The barrier island sere is much more diversified and consists of four subsystems: 1) bird keys and banks, 2) dunes, 3) transition shrub zones, and 4) maritime forests (Sandifer et al. 1980:108-109). The bird key and bank subsystem is located on small, isolated islands (ie sand spits and swash bars) in tidal inlets and larger bays. These islands are geologically unstable, tend to migrate, and are subject to tidal flooding, especially in the spring. Vegetative cover is generally minimal and can be divided into marsh and dune communities (Gaddy 1977). Marsh communities consist of glasswort flats, smooth cordgrass, and mixed smooth cordgrass-sea purslane-glasswort associations. Higher up, dune communities of saltmeadow cordgrass, saltmeadow cordgrass-panic grass, panic grass, and mixed shrub-forb-grass associations dominate. The latter association occurs at the apex of the more stable keys and is predominantly comprised of dog fennel, camphorweed, beach elder, sea myrtle, and saltmeadow cordgrass. Approximately 60 to 80 percent of the area of key islands is non-vegetated and consists of bare sand and mudflats.

The remaining three subsystems are distributed in distinct concentric zonal patterns on barrier islands. The dune subsystem is found on open dunes (i.e. those directly exposed to the ocean) and essentially represents a more diversified key vegetation. Sea oats tend to dominate the open dunes of South Carolina barrier islands, with the exception of those in the Santee delta, which are numerically dominated by panic grass (Pinson 1973). Other important species found on the open dunes include saltmeadow cordgrass, sand grass, camphorweed, beach elder, euphorbia, horseweed, evening primrose, and beach pennywort. The transition shrub subsystem is located inland from the open dunes and occupies the slopes of old or closed dunes and interdune slacks.

Two generalized communities are recognized for this subsystem (Bozeman 1975; Sharitz 1975). One of these is the dune-forest shrub thicket, situated below the seaward margin of the maritime forest. This community is characterized by a sheared or "espaliered" canopy of no more than about two meters in maximum height. Usually vegetation is dense and owes its scrubby character to ocean spray. The principle dominants on the South Carolina islands are wax myrtle and yaupon holly (Rayner 1974). Other important species include dwarfed examples of live oak, eastern red cedar, red bay, and numerous vines. The landward margin of the maritime forest supports the second transitional community type, the marsh-forest shrub thicket. This community appears to be controlled by high spring tidal flooding and because of the lack of ocean spray the transition to forest is narrow and abrupt. Dominants on South Carolina islands include sea myrtle, marsh elder, sea ox-eye, black needlerush, sea lavender, salt marsh fimbrystilis, orach, switchgrass, broom sedges, and seaside goldenrod (Hosier 1975; Tiner 1977). Higher elevations on marsh islands also support this type of community.

The maritime forests of the barrier islands occur on the higher, central ridges where there is greater protection from salt spray and winds. Sharitz (1975) distinguishes five types of maritime forest community in South Carolina: 1) oak-pine, 2) oak-palmetto-pine, 3) oak-magnolia, 4) palmetto, and 5) low oak woods. The oak-pine community contains a supercanopy of loblolly and longleaf pines and a secondary canopy of laurel oak. Other important arboreal species include red bay, hickories, cabbage palmetto, and sweet gum. The shrub layer is dominated by yaupon holly, American holly, red bay, and blueberry. The oak-palmetto-pine community occurs at the edge of the transition shrub communities and supports a supercanopy of laurel oak, cabbage palmetto and loblolly and longleaf pines. Live oak and southern red cedar form important species of the subcanopy, while the shrub layer is dominated by yaupon holly and red bay. The oak-magnolia community is dominated by laurel oak, live oak, magnolia, and red bay, although pines are also present in the supercanopy. The Palmetto community is common at the edges of ponds and is dominated by the cabbage palmetto and laurel oak. Lower percentages of pines, wax myrtle, southern red cedar, and magnolia contribute to the impoverished supercanopy. The low oak woods community occurs as a narrow band adjacent to transitional shrub communities. The upper canopy is sparse and low and consists primarily of live oak and occasional pines. Scrub laurel oak, wax myrtle and red bay comprise the dominants of the subcanopy. There is a general consensus that the oak-magnolia community represents the climax vegetation of the maritime forest, while the others are either successional or subclimax in nature; but these relationships are not well understood (Oosting 1954; Sandifer et al. 1980). The Pleistocene sea islands and the mainland live oak strand support forest communities that resemble the oak-palmetto-pine community of the barrier islands.

The mainland live oak strand faunal assemblage is similar to the upland ecosystem of inland locations, with some important avian additions. The sea and barrier islands, however, exhibit distinctive differences due to the rather restricted and specialized habitats that form on islands. Generally, the larger an island is, the more diverse its plant and animal associations are. Other than slightly lower species diversity and density there are very few differences between the mainland strand and the larger sea islands. The fauna of the keys and most of the barrier islands situated at substantial distances from the shore, though, are much more restricted in both species diversity and density.

There are virtually no permanent inhabitants of the keys and banks because of the instability of the landform and periodic inundation, especially during spring high tides. Nevertheless, these islands serve as important nesting grounds for a number of avian species including the brown pelican, royal tern, snowy egret, laughing gull, Louisiana heron, black skimmers, royal least, gull-billed terns, American oystercatchers, plovers, willets, and boat-tailed grackles (Shanholtzer 1974). Insects constitute the other major faunal class occupying the keys and banks. Carolina diamondback terrapins and the ghost crab also make use of this habitat for various purposes.

The barrier islands support a more diverse fauna. Amphibian species are not common due to the lack of suitable freshwater habitats. Frogs, toads, and a limited number of salamanders are restricted principally to the forest habitats where appropriate moisture conditions are sometimes present. Lizards (i.e. broadhead skink, green anole, ground skink, five-lined skink island glass lizard) and some of the larger snakes (i.e. banded water snake, eastern garter snake, eastern ribbon snake, southern black racer, corn snake, northern scarlet snake, yellow rat snake, cottonmouth, and eastern diamondback rattlesnake), however, are abundant. Breeding populations of alligators are also common on the larger islands. Non-marine turtles are rare, but on the larger islands the gopher tortoise and the eastern mud turtle are sometimes spotted. The transitional shrub community supports an impoverished list of only about 24 avian species, while the maritime forests are credited with 83 avian species (Sandifer et al. 1980). Mainland and sea island live oak strand forests support an even greater number of species than like habitats on the barrier islands. Dominant species of the maritime forest parallel those of the upland ecosystem and include two species of hawk, the great horned owl, wrens, flycatchers, hummingbirds, crows, robin, catbird, three species of woodpecker, vireos, warblers, and other insectivores. The larger islands also support a mammalian fauna similar to the upland ecosystem. In pre-settlement times this included the white-tailed deer as well as major predators such as the black bear, cougar, gray wolf, and bobcat (Sanders 1978).

Saltmarsh Ecosystems

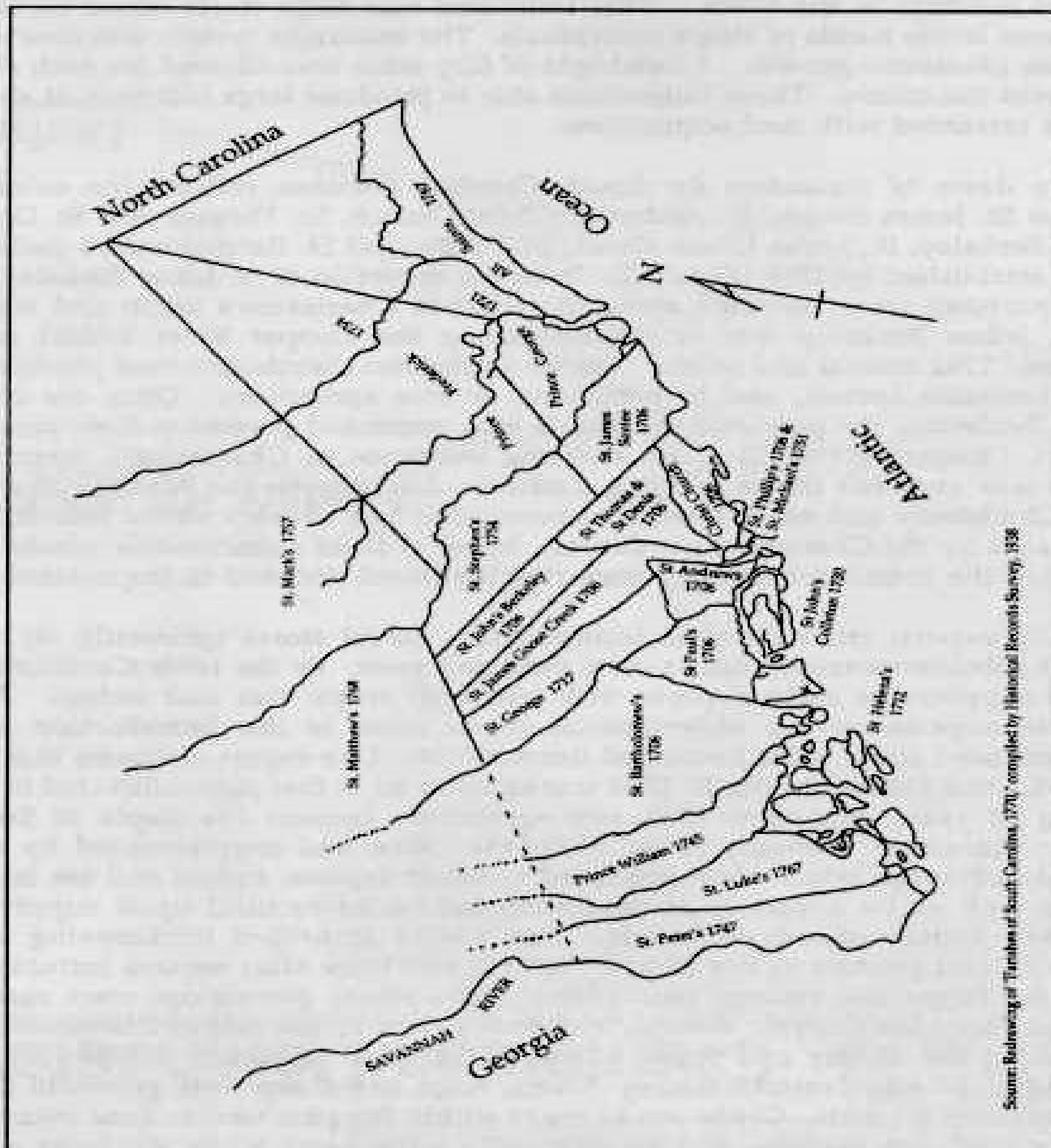
Saltmarshes occupy the near shore shelf, tidal creek mouths, and the edges of drowned river valleys and inlets. Vegetation is distributed in a series of distinct zones in salt marshes in response to varying degrees of salinity and immersion (Sandifer et al. 1980). Saltmarsh cordgrass lines the banks of tidal creeks, while saltmeadow cordgrass comprises the main element of the vast cordgrass plains of the near shore shelf (Silberhorn 1982). In areas closest to shore that are exposed to air for extended periods during low tide, other salt-tolerant freshwater species such as spike grass, blackgrass, sea lavender, glasswort, and saltmarsh bulrush form a distinct zone in association with cordgrass species.

The most abundant and important fauna of the saltmarsh ecosystem are crustaceans and birds (Sandifer et al. 1980, Shealy et al. 1974, Zingmark 1978). Dominant crustaceans, predominantly distributed along the tidal creeks, consist of mud, sand, and brackish water fiddler crabs, marsh crabs, blue crabs, grass shrimp, marsh periwinkle, eastern mud snail, saltmarsh amphipod, and Atlantic ribbed mussel. The bird fauna include the same list as that of the keys and barrier islands with the addition of a wide range of wintering aquatic birds which rarely utilize the shore. Some of the more common of these include the snow goose, Canada goose, northern shoveler, mallard, and northern pin tail. Fish fauna are limited and primarily consist of small, shallow water species including the sheapshead minnow and sailfin molly. A large number of reptilian species are concentrated in the tidal creek mouths, especially alligator, cottonmouth, diamondback terrapin, snapping turtle, and southern water snake. Muskrat and raccoon utilize the tidal creek mouths and immediate shoreline.

Estuaries and Bays

Estuaries and bays are generally situated seaward from, and adjacent to, saltmarshes in deeper water, and contain a significant amount of freshwater-saltwater admixture. The mixture is graded and changes from brackish in the estuary, to brackish-marine at the opening to the bay, to marine in the outer portions of bays. This ecosystem supports a rich and concentrated crustacean, piscine, and avian fauna (Sandifer et al. 1980). Dominant crustaceans include the eastern oyster, whelk species, hard clams, tellin, stout tagelus, quahog, conch, drills, Atlantic ribbed mussel, crab species, shrimp species, scallops, starfish, and Atlantic purple sea urchin. Piscine dominants include sharks, rays, snapper, striped bass, American shad, Atlantic croaker, black drum, gar, sturgeon, sea catfish, mullet, and white flounder. Avian dominants include those described for the maritime ecosystem and a diverse set of wintering aquatic birds including the American coot, black scooter, blue-winged teal, brant, bufflehead, canvasback, common eider, greater scaup, mallard, mottled duck, mute swan, northern pintail, northern shoveler, ring-necked duck, roseate spoonbill, snow goose, Canada goose, ruddy duck, and tundra swan. In pre-settlement times the ranges of two large sea mammals, the harbor seal and the manatee, extended along the South Carolina coast as well. The estuarine and bay ecosystem is not particularly rich in species when compared to most terrestrial systems, but the tendency for certain species to occur in great concentrations not only has significant economic implications today, but was also critical to prehistoric populations of the Sea Islands Coastal Region. Some of the more important high-yield estuarine resources to protohistoric and prehistoric coastal groups were oysters, clams, anadromous fish, and probably wintering aquatic birds (see Crook 1986; Espenshade and Brockington 1989; Larson 1980; Milanich 1971; Pearson 1984; Trinkley 1980).

Figure 3. 1770 parish divisions of the lowcountry



III. Cultural and Historic Background

This chapter will discuss the record of the various human cultures that have existed in the Charleston Harbor region over the last 12,000 years. The first section discusses the prehistory of the region, while the second section presents an overview of the historic occupation.

Prehistory

It is almost always the case that the first order of business for any archaeologist charged with studying extinct cultures in a particular region is to construct a chart relating the various cultures he has identified through the analysis of distinctive artifacts with a time scale. This is called a culture chronology and it serves as the primary basis by which the archaeology of a region is interpreted. We have a fairly detailed record of human occupation across North America from about 12,000 years ago to the present. It was at about 12,000 years ago that the last ice age ended and the continent was filled-in with an ancient hunting culture we refer to as Clovis. Large ice age game animals, such as the wooly mammoth, mastadon, glyptodon, ground sloth, large forms of bison, and saber-toothed cats, were still quite abundant at this time and the Clovis people, at least in part, hunted these large animals. It is commonly held that the Clovis hunters were the first occupants of the New World, migrating from Asia across the land bridge connecting Siberia and Alaska at the end of the ice age. This is by no means established, however, and as we delve more deeply into the subject new evidence is slowly emerging to suggest that the Clovis people were preceded by numerous more ancient cultures.

The big game animals rapidly declined after 12,000 B.P. and the Clovis hunters were forced to adapt to changing environmental and economic conditions. The next stage of cultural adaptation throughout the New World is identified by archaeologists as the Archaic Period. Archaic groups were hunter-gatherers, subsisting on wild plant and animal resources and leading rather nomadic and mobile lives. The Archaic Period is calibrated to begin at about 10,000 B.P. and to last until about 3,000 B.P. Over this time period there were many subtle changes in the character of adaptive responses as climate changes and population pressure increased, particularly toward the end of this period. Late Archaic groups (ca. 4,000 to 3,000 B.P.) were forced to intensify their economic patterns as pressure on resources increased as human populations became larger and they began to settle more permanently in villages. Technological innovations were also introduced, among them stone bowls, pottery, and in some regions horticultural and agricultural techniques for food production.

This set the stage for the next major phase of cultural adaptation in the eastern United States, the Woodland Period. The Woodland period in the Southeast lasted from about 3,000 to 800 B.P. We do not yet have a very clear picture of how Woodland people lived and the details seem to have varied substantially from one region to the next. In South Carolina it would appear that the Late Archaic pattern of semi-nomadism and low level subsistence intensification continued throughout most of this time period.

The final prehistoric cultural stage is referred to as the Mississippian (ca. 800 to 450 B.P.). The Mississippian Period saw major changes in the character of life. Economies shifted to intensive corn agriculture, inter-regional warfare increased in frequency, the more egalitarian leadership of the Woodland Period was replaced by centralized chieftainships, and groups began to live in permanent villages characterized by palisaded surrounds and burial and temple mounds. This system collapsed during the late 15th and 16th centuries throughout the Southeast. This may have been the result of introduced epidemic diseases brought in by the Spanish explorers and missionaries, but other factors pre-dating European contact may also have contributed as many of the large Mississippian centers such as Moundville and Etowah were abandoned in the early to middle 15th century, long before the Spanish arrived in the New World.

Each of these periods will be discussed in more detail below. Specific references to the Charleston Harbor area will be presented when appropriate.

Paleo-Indian and Early Archaic

The consensus view of Paleo-Indian (ie. Clovis culture and its immediate descendents) occupation in the Southeastern United States is that it was characterized by high range (territorial) mobility, low population density, and a focal hunting economy (Anderson and Joseph 1988; Gardner 1979; Goodyear 1979; Goodyear et al. 1989; Meltzer 1988; B. Smith 1986; Steponaitis 1986; Williams and Stoltman 1965). Differences of opinion begin to emerge when the specific details of this overall adaptation are considered. Building on Binford's (1980) generalized model of hunter-gatherer mobility, it has been argued that early Holocene mobility patterns should have shifted from logistically based settlement systems to more residentially mobile systems as temperatures warmed (see Cable 1982). Contrary to the traditional view (see Caldwell 1958) of a gradual shift toward more sedentary systems through time, then, this model argues that the earliest post-Pleistocene populations may have maintained more stable residences than those of the later early Holocene and Middle Holocene. Several subsequent studies in the Carolinas (Anderson and Hanson 1988; Anderson and Schuldenrein 1983,1985; Blanton and Sassaman 1989: Cantley et al. 1984; Sassaman 1983, 1990) have lent general support to this hypothesis.

A number of settlement models have implicated the Fall Line as the hub of territorially expansive settlement systems during the Early Holocene along the Atlantic Slope. Noting the apparently heavy concentration of Paleo-Indian points in this zone, Goodyear (1983; Goodyear et al. 1989: 44) has speculated that this pattern either evidenced disproportionately high reoccupation at the Fall Line or its use as a zone of base camp habitation of prolonged seasonal nature. Anderson and Hanson (1988) later elaborated on this general scheme by proposing a seasonal round for Early Archaic systems in which the Piedmont was exploited during the summer and early fall, the Coastal Plain was targeted in the spring, and the Fall-line was inhabited during the fall and winter. Occupation of the Fall-line is characterized by the establishment and/or reoccupation of fall aggregation sites and winter base camps, while the Piedmont and Coastal Plain are hypothesized to have been exploited by dispersed foraging units. It is further proposed that the territories of Early Archaic bands were organized linearly along major drainages and that the South Atlantic Slope contained eight such bands distributed from northern Florida to Pamlico Sound, N. C. The interior Coastal Plain is hypothesized to have been exploited through the formation of small forager residences and specialized logistical extraction camps. Settlement along the coast is poorly understood because the early Holocene coastline is now buried and evidence documenting the use of shellfish and other coastal resources represents a major lacuna in Archaic research.

Middle Archaic

Middle Archaic sites throughout the region are characterized by redundancy and low diversity and it is argued that these qualities reflect a settlement strategy of high residential mobility (Sassaman and Brooks 1990). Climatic and environmental pressures to adjust settlement systems in the direction of greater residential mobility in the middle Holocene may have been offset at some point, however, by range reduction due to tighter population packing (Anderson and Joseph 1988: 130-131). One pattern demonstrating range reduction is the distinctive shift toward heavy reliance on local lithic materials during the Middle Archaic (Blanton and Sassaman 1989). Major range reduction has been postulated (Sassaman and Brooks 1990), in the context of the middle Holocene adaptive environment, to have led to circumscription of the original Early Archaic river-extensive territories and the splitting of the Coastal Plain and Piedmont segments into separate band territories.

Greater residential mobility may very well have typified the later Early Archaic and early Middle Archaic settlement systems regardless of gradual range reduction processes (see Sassaman and Brooks 1990). Other factors emerging at the end of the Middle Archaic Period may have hastened a shift toward a new type of logistical strategy within much reduced ranges. One such factor affecting the coastal plain and coastline was the formation of swamps and estuaries as sea level began to stabilize (Brooks et al. 1989). Moreover, the middle Holocene climate appears to have been drier, but also more variable, suggesting to Blanton and Sassaman (1989) that at least the Coastal Plain environment was changing toward a greater degree of patchiness and therefore would have presented Middle Holocene foragers with the opportunity to exploit an environment with increasing spatial resource segregation. Consequently, pressures toward a reversion to logistically oriented settlement systems may have been manifest earlier in the Coastal Plain than in the Piedmont.

Late Archaic and Woodland

Numerous studies have argued that the early emphasis on sedentism that is manifest in the dramatic appearance of terminal Late Archaic shell rings and midden sites, and also the subsequent pressures toward settlement dispersal and residential mobility during the Woodland period, were the consequence of complex ecological changes of the coastal landscape brought about by sea level rise and fluctuation over the past 5000 to 6000 years (see Anderson 1982:376; Brooks et al. 1989; Colquhoun et al. 1980; DePratter and Howard 1977; Trinkley 1989:78). A rather dramatic transgressive trend in sea level during the middle Holocene began to level-off (Colquhoun et al. 1980) and pollen sequences suggest that pine was replacing oak as the dominant forest arboreal as a consequence of a wetter climate and more hydric soil conditions (Brown 1981, Watts 1971). As sea level began to stabilize after about 5,000 B. P. the modern estuarine ecosystems were established and the interior river swamps attained their maximum expression. Sea level has never completely stabilized since the end of the Pleistocene, and a series of 1-2 meter fluctuations have been documented for the period spanning 4,200 to 800 B. P. (Brooks et al. 1986).

Brooks et al. (1989) have related this sequence of environmental changes to perceived changes in the geographic distribution and structure of terminal Late Archaic and Woodland shell middens and terrestrial sites on the South Carolina Coastal Plain. Late Archaic shell middens are associated with the initial formation of stable estuaries in the region and although they represent rather sizeable heaps of shellfish refuse, it is possible that a number of the middens which formed during the regressive interval (dated to 3800 B. P.) are now submerged below modern sea level. Moreover, a regressive interval between 3,100 and 2,100 B. P. may be responsible for burying Early Woodland shell middens along the coast (see also DePratter 1977, DePratter and Howard 1981).

Some Late Archaic shell middens are not only large, but also contain a broad range of estuarine and terrestrial subsistence resources and a high diversity of artifactual material, characteristics that have led a number of individuals to suggest that these early shell middens represent intensive multiseasonal habitations (see also Combes 1975, Hemmings 1970, Michie 1974, 1979, Trinkley 1976, 1980). These stand in sharp contrast to the bulk of the shell middens dating after 3,000 B. P., which are small, thin middens with low artifact density and tool diversity. These later middens are also more numerous and dispersed in distribution, and rather than occurring exclusively along the seaward margin of the mainland and on sea islands, they tend to be located up the mouths of major channels and along the smaller tidal creeks. Brooks et al. (1979:94) suggest that these differences are the result of estuarine expansion as sea level gradually rose over time to its current elevation. It is suggested that these conditions were conducive to major changes in the distribution and structure of estuarine resources, especially shellfish which became more dispersed in distribution. It is inferred that the shift in resource structure required adjustments in Woodland settlement systems that entailed seasonal dispersal into small social units to effectively exploit the estuaries. Over-exploitation of the largest bars along the mouths of channels might also have contributed to this finer-grained Woodland exploitative pattern (see Trinkley 1981).

Late Archaic systems of interior coastal plain rivers also appear to have been significantly affected by these changes. The documentation of intensively occupied upland settlements from this time period in the Middle Savannah River Valley has led to a reconstruction that stipulates spring and summer aggregation along the river terraces and fall-winter household dispersion into the headwaters of upland creeks (Brooks and Hanson 1987; Sassaman 1983; White 1982). Furthermore, there are indications that the aggregation sites can be grouped into two hierarchical levels, with the largest sites of this type occurring at the Fall Line (i.e. Stalling's Island, Lake Spring) and Coastal (Bilbo, White's Mound, Cox) ecotones. The higher order Fall Line aggregation sites are speculated to represent locations where communal anadromous fish harvests were organized and appear to have also served as seasonal villages. Lower level aggregation sites occur near the mouths of tributary streams and they are speculated to represent specialized staging areas for residential groups prior to summer dispersal.

The character of shell midden morphology and dimensions changes dramatically during the the Early and Middle Woodland periods along the South Carolina and Georgia coasts, and may reflect strategic shifts toward settlement patterns similar to those chronicled in the ethnohistoric accounts. The large Late Archaic middens and rings disappear and the remaining shell middens consist of small, diffuse scatters apparently indicative of short term, seasonal occupation by small groups. Many of the sites of these periods, in fact, do not even contain shell. Trinkley (1989:79-80) has suggested that this reduction in size and increased dispersion of shell middens represents fragmentation of the earlier Late Archaic pattern due to the inundation of tidal creeks and the subsequent destruction of established shellfish bars (see also Michie 1980). In the interior coastal plain this period is said to be marked by a diversification of site types and settlement locations and the hypothesis has been advanced that such a pattern indicates increased subsistence intensification directed toward a variety of previously under-exploited riverine and upland resources (Espenshade and Brockington 1989: 233-239; Hanson 1982, Stoltman 1974, see also Cohen 1977). The primary factor cited for this subsistence shift is population increase and packing.

The nature of Middle and Late Woodland settlement is perhaps the least well known of any of the ceramic bearing occupations throughout the region. The standard representation for Middle Woodland (i.e. Deptford) settlement systems along the central South Carolina coast derives is credited to Milanich's (1971:214-215, Milanich and Fairbanks 1980:71-75) seasonal transhumance model developed for Deptford occupations in Florida. The model stipulates that populations in coastal locations maintained a biseasonal settlement pattern involving alternating winter-summer habitations on the coast to exploit marine and estuarine resources and fall habitations in the interior to gather nuts and hunt terrestrial game. The coastal habitations, which are associated with the maritime live oak strand, are characterized as small, semipermanent, non-agricultural villages, while the inland habitations are hypothesized to represent temporary fall encampments occupied by separate nuclear family units. Structural remains from one of the hypothesized Deptford winter villages in coastal Georgia indicate sizes corresponding to nuclear family units and from this Milanich suggests a village population of 25 to 60 persons given site size relationships. Thus, Deptford villages are characterized by smaller populations than those purportedly associated with ethnohistoric groups in the area, according to Jones' (1978) model, and a subsistence base comprised exclusively of wild resources as opposed to a mixed agricultural economy. There is evidence to suggest that Middle and Late Woodland subsistence-settlement patterns in the region were more diverse and less dependent on coastal resources than those of Mississippian groups (Brooks and Canouts 1984:250-255; Brooks et al. 1989:96), but the details of these patterns have not yet been effectively modeled.

Mississippian and Protohistoric

Lewis Larson (1969, 1980) undertook the first major attempt to model Mississippian adaptive variation along the Southeastern Coastal Plain. For his purposes the study area was divided into three adaptive regions: (1) the coastal sector, (2) the pine barrens, and (3) the south Florida sector. The latter is outside of the scope of the present overview. The coastal sector corresponds to the thin band (ca. 1 to 2 miles in width) of magnolia-live oak fringe running along the coastal margin and includes all of the land forms affected by daily tidal change (i.e. sea islands, stream mouths, tidal creeks, barrier islands, marsh islands, marshes, and the mainland marsh-lagoon). The pine barrens sector extends from the interior edge of the coastal sector to the Fall-line. A major thesis of Larson's study was the contrasting adaptive environments presented by these two sectors. The pine barrens were characterized as relatively devoid of subsistence opportunities for Mississippian populations, in both the uplands and along the stream floodplains. It was argued that the long-leaf pine forests supported only very low game populations due to the scarcity of nut mast from hardwoods and that the xeric upland soils and poorly drained floodplains were ill-suited for agriculture using aboriginal techniques of production (Larson 1980:56-59). By contrast, the coastal sector, and in particular the lagoon and marsh section of the mainland, was characterized as relatively food-rich and the locus of intensive Mississippian occupation.

Based on ethnohistoric accounts of the Guale of coastal Georgia, Larson provided a number of more specific observations concerning the seasonal round of subsistence activities along the Atlantic coast. Although the Guale were located a good deal to the south of the Charleston Harbor area they nevertheless appear to provide a useful analogy for the nearby Cusabo who were closely affiliated with the Guale in the sixteenth century. The primary elements of the Guale seasonal round consisted of summer swidden agriculture, fall nut harvesting and deer hunting, and winter exploitation of shellfish and other estuarine resources. The winter and spring were identified as seasons in which dependence on stored foods, primarily nuts and corn, was necessary to insure minimal caloric intake. Larson (1980:224-226) demonstrated this point through a discussion of subsistence data derived from the Pine Harbor Site in McIntosh County, Georgia. Here, small and diffuse shell middens were sample excavated, each of which, according to Larson, represented the accumulated debris from a single household over a period of either one or two years. The most abundant remains in the middens, of course, were shellfish species, primarily oyster. Small numbers of deer, raccoon, bobcat, opossum, and rabbits were also present. It was estimated that the average daily caloric yield of oyster meat per household member would have been somewhere between 650 and 800 calories, well short of the daily caloric requirements for sustaining life. Consequently, Larson was able to infer heavy reliance on stored agricultural and nut resources during the winter at the site.

Far and away the most detailed model of Mississippian social organization and subsistence-settlement pattern for the Georgia and South Carolina sea islands has been presented by Morgan Crook (1986:11-33). Crook=s model draws heavily upon Guale and Cusabo ethnography and marine ecology to extract and build upon Larson=s (1969, 1980) model of coastal sector adaptations. The basic elements of this adaptation included: (1) swidden agriculture, (2) a town-oriented settlement system, (3) a chiefdom-like political organization comprised of various levels of micos and several other offices, (4) matrilineal kinship systems, and (5) matrilocal residence rules.

At the time of Governor Pedro de Ibarra=s visit to Guale in 1604, Crook notes that three regional town groups were extant, each administered by a regional mico who assumed a position of authority over lesser micos representing each town within a group. The locations of Ibarra=s council meetings on St. Simons, Sapelo, and St. Catherines islands are inferred by Crook (also Swanton 1922:81, 89) to represent the centers of these three regions. Citing Swanton (1922:84) as an authority, Crook also suggests that the regional micos were administered by a paramount chief or head mico. Within the town administration, Crook suggests that Guale micos served a similar function to that described by Speck (1907:113) for Creek micos: @to receive all embassies from other tribes, to direct the decisions of the town council according to his judgement, and finally to stand as a representative of the town in foreign negotiations.? Based on documentation from the Ribault expedition of 1562, he further speculates that micos played a commanding role in food redistribution (see Bennett 1975:43). Whether micos assumed their positions on the basis of ascribed or achieved status is not clearly discussed in the available documentation.

Crook suggests that Guale town plans were structured in such a way as to reflect the various segmentations of this political organization. Guale council houses served a similar function to Creek Tcokofas or rotundas. They were large, circular in shape, and were situated in a public sector of the town in association with other such spaces including ball grounds. That the Guale conducted ball games in a chunky yard not unlike those described for the Creek is confirmed by San Miguel=s observations of 1595 in the southern Guale area (see

Garcia 1902 as translated in Larson 1978:131). Although noting that very little is actually said about common domestic houses other than that they were small and used only for shelter (see Garcia 1902 as translated in Larson 1978:131), Crook infers that they were round as were those of the contemporary Timucua as depicted by DeBry's engravings of LeMoyne's paintings (see Lorant 1946). Creek households of particular lineages were generally clustered in specific sectors of towns (see Swanton 1928:79-97, 170-171), and Crook infers that this form of spatial organization was extant in Guale towns as well. Food storage space was apparently provided by graineries, which, according to Ore (1936:24), were raised barn-like structures. It is inferred that at least some of the Guale towns were palisaded, but there is no mention of platform mound structures.

Crook recognizes four subsistence phases of the Guale annual cycle. These included: (1) the summer swidden harvest, (2) fall nut gathering and deer hunting, (3) winter estuarine fish and shell-fish harvesting, and (4) the spring stress period. The spring stress period corresponded to a time of low availability of wild food crops and increased demands on bulk labor output to clear and plant swidden plots. Primary sustenance during this period derived from stored foods with the exception of anadromous fish runs, which may have entailed relocation well up into the interior after the spring planting. Crook (1986:19) infers that Guale agricultural fields were scattered throughout the highland ridges of the interior and were subject to a fallow rotation system. Settlement at this time would have entailed dispersed social units consisting of one or two closely related nuclear families. Here, Crook relies mainly on the observations of

Jesuit priest Juan Rogel who found himself among the Orista of the Port Royal Sound area in 1570 (see Zubillaga 1946). Rogel reported that the 20 households comprising the town of Orista dispersed into 12 or 13 @farms? during the early spring to plant their crops.

Agricultural harvests occurred in mid-summer and at this time the dispersed farmsteads aggregated at town locations to hold ceremonial feasts. From this point until the acorn harvests in early fall (mid-September), seasonal population aggregations were maintained in the towns which were sustained by agricultural stores and low level foraging forays. Crook speculates that it was at the time of harvest that the town granary, administered by the mico, was replenished with agricultural produce.

Owing to the concentrated but quickly perishable nature of acorn and hickory nut availability, Crook argues that hardwood groves in the highlands would have been most effectively exploited by relatively large and mobile social units. Relating this to the Guale social structure model, he accordingly infers that the unit would most likely have corresponded to a matrilineal segment comprised of as many as 4 or 5 nuclear families. This would have provided an equally advantageous situation in which to conduct relatively large communal deer drives, since deer would also aggregate in these areas to feed on mast. Rogel also observed that these acorn gathering groups aggregated twice in two months at different locations in Orista. Such assemblies would have provided an opportunity to deposit acorn harvests and dried venison in town stores. Crook speculates that the micos and their families may have inhabited their towns throughout this season, harvesting oak and hickory groves in the immediately adjacent areas. Settlement during this subsistence phase would be expected to resemble that of a shifting foraging adaptation, with new harvesting camps being established as a perceived threshold of resource depletion was reached.

Crook (1986:22-25) infers a winter subsistence phase from an in depth analysis of estuarine population dynamics. It is during this phase that most estuarine mollusks (e.g. oysters) attain their greatest body weight and a number of fish (Atlantic herring, blueback herring, gizzard shad, sturgeon, spotted sea trout, Atlantic croaker, star drum, etc.) attain their greatest availability. The principal concentrations of these species during the winter months occur along the tidal creeks and Crook argues that the matrilineage segments would have shifted settlement to the margins of these creeks to exploit the estuaries. He further suggests that these winter settlements may have been more stable than the fall acorn camps, where residential moves may have occurred on a weekly basis. These winter settlements would have been partially sustained by fall nut stores as well as estuarine fauna.

A major problem with Crook's (1986) model, and one he also acknowledges, is the validity of Jesuit and French records originating several generations after initial Spanish contact to accurately model pre-contact patterns (see Milanich 1986). An in depth consideration of this very issue was undertaken by Grant Jones (1978) in his ethnohistoric study of the Guale coast through 1684, a study that Crook fails to site. Jones (1978:171-178) argues that the apparently high residential mobility of contact groups was more a function of bad relations with the Spanish than an indication of the typical settlement pattern, and that the pre-contact pattern was probably much more stable and sedentary. Although his overall interpretation of Guale seasonal movements does not differ substantially from that of Crook=s, Jones argues that agricultural fields were tethered to a central town and that the Jesuit characterization of this facet of the settlement pattern as scattered is somewhat exaggerated by the circumstances surrounding poor contact relations. Jones (1978:194) describes such settlements as @dispersed towns? in which the town center was small and the bulk of the population was dispersed in farmsteads around it. The structural organization of the Guale @dispersed town,? then, would consist of a central area containing the residences of the mico and possibly his close kin, a large, circular council house or *buhio*, a chunky yard, and sometimes a charnel house, and a perimeter residential zone comprised of loosely scattered domiciles and agricultural fields.

Certainly such sites as Pine Harbor and Red Bird Creek provide some support for the hypothesis that Mississippian villages in the region may have been occupied throughout the year. The Red Bird Creek Site (Pearson 1984:3-11) is situated on the seaward edge of the mainland directly adjacent to a salt marsh in what Larson (1980) would describe as the marsh and lagoon section of the Coastal Sector. When Red Bird Creek was originally discovered, it was said to consist of a series of 25 thin, oval-shaped shell middens, one definite burial mound, and one potential burial mound. These features were arranged in a linear area measuring approximately 160 m by 40 to 60 m, or approximately 2 acres. Excavations exposed a portion of a burned, squarish, wall-trench house measuring 4 m to 5 m on a side and portions of 5 shell middens. In addition, disarticulated burned and unburned human skeletal fragments were recovered from the burial mound. The shell middens, like those at Pine Harbor, were small, ranging between 2 and 8 m in diameter and exhibited variably complex stratigraphy, some containing ash lenses. These were interpreted as representative of primary deposits of the domestic trash of nuclear or extended families and it was speculated that each area would contain a domestic residence. Subsistence data from the site indicated a broad spectrum exploitation pattern of all nearby maritime and inland ecosystems and established a heavy reliance on agricultural crops, particularly corn.

Pearson (1984:34-35) concluded, on the basis of these various lines of evidence, that Red Bird Creek was a permanent or semi-permanent settlement, representing a moderate-sized Mississippian village with dependency ties to larger contemporaneous villages. As Crook (1986) points out, however, the appearance of year-round permanency might result from the complexity of social unit movements. In his model, the central portion of the site where the mico resided may have been occupied year round while adjacent, peripheral residences would have temporarily abandoned. Moreover, Crook identifies certain periods of aggregation during seasonal dispersal that might very well have taken place at the main villages. The issue of occupation stability and continuity will be left unanswered until a much broader sample of the residential contexts at village sites is obtained.

The degree to which ranking manifested itself in the social fabric of the Mississippian cultures of the region is another topic of some debate. Both Crook (1986) and Jones (1978) suggest that the paramount chiefdom model that they infer for the Guale and Cusabo can be extended back into the late prehistoric period. It should be appreciated, however, that counter models of social organization could be generated using the same ethnohistoric accounts that these authors cite. It is interesting in this regard to note an observation made by San Miguel during his 1595 visit to the southern Guale towns (Garcia 1902). Here the mico=s standard of living was not distinguished from any of the other residents and his house was not appreciably larger either. Jones (1978:199) suggests that this apparent decline in status was the product of continued European contact and that the pre-contact pattern was much different and reflective of regional chiefdom organization. It is certainly true that there existed a number of influential individuals at the time of early contact that would possibly fit the description of chiefs in a very broad sense (see Bennett 1975), but whether this represented a multi-leveled decision making hierarchy controlled by a paramount chief is a matter that cannot be established on the basis of current documentation.

One of the somewhat conspicuous omissions from the ethnohistoric literature is any concrete mention of platform mounds as integral elements of Guale town plans. There is, in fact, only one confirmed reference to any earthen structure being raised above the ground. This was San Miguel=s description of a community building at the *mico mayors* town in Asao (Garcia 1902:198). This building was a large, circular jacal constructed of large pine logs bunched together at the top that was supported by a platform bed standing about a meter in height. Certainly this description indicates mounding of a sort, but it would seem to represent only a small and vestigial element of mound building rather than a continuance of the monumental earth works of the Mississippian period.

An obscure reference written by Oviedo (1959:328) and attributed to the Allyon expedition of 1526 about elite charnel houses might serve as a better example of mound building. These temple ossuaries were described as containing walls of lime and stone of about 3 meters in height above which were pine walls. The date of this information could possibly establish a closer link with the late prehistoric Mississippian period than the Asao example and would tend to support Jones’ explanation. However, the Oviedo document is problematic. It is not known where on the Atlantic coast the Allyon party landed, although it would appear that the location was considerably north of Guale territory (see Swanton 1946:), and, moreover, it is unclear from the description just how these elite temples were incorporated into the cultural system, if at all. A close evaluation of Oviedo’s description indicates that these structures were located away from their apparent associated communities and sometimes were separated by being placed on small islands. Thus, it is entirely possible that Allyon’s party located the ruins of abandoned Mississippian platform mounds that were erroneously inferred to be associated with the contemporary communities they visited. Alternatively, these isolated structures may simply have been reused by these groups to perform functions not corresponding to their original intended context.

History

The following narrative provides a brief historical context for the Charleston Harbor area. It begins with the period of contact between local Native American groups and European settlers and touches on the various succeeding periods of occupation including the colonial, Antebellum and Bellum periods.

Historic Contact

> *I cannot quit the Indian without mentioning an observation that has often raised my wonder. That in this province, settled in 1670... then swarming with tribes of Indians, there remain now, except the few Catawbas, nothing of them but their names, within three hundred miles of our seacoast... nor {is there] any accounting for their extinction by war or pestilence equal to that effect* (William Bull, Lieutenant Governor of South Carolina 1770 as quoted in Weir 1983:24).

Bull's observation of the dwindling numbers of Native Americans was on target but his thinking upon the causes of the virtual disappearance of the native groups fell far short of the mark. He was looking for a single, catastrophic reason for their extinction rather than reflecting on the many factors that caused the collapse and disappearance of Indian cultures on the South Carolina coast. While the first relationships European settlers forged with Native American groups were economic in character, the trade networks were decidedly cast in favor of the Europeans. Guns, pistols, hatchets, axes, hoes, knives, swords, cloth, clothing, jewelry, mirrors, ribbons, stockings, salt, gunpowder, and brass kettles were some of the goods which changed hands (Anderson and Logan 1981:35). Trade goods were exchanged for food and security against hostile behavior. Increased trade brought about greater dependence upon Europeans as traders outfitted Indian hunters on credit which was to be paid back in skins and slaves (Anderson and Logan 1981:36). Many, forced into debt, were unable to bound back economically and Indian land kept diminishing as the European presence grew.

Their fields became the nucleus of European farms and plantations, as Europeans took advantage of the cleared areas. The environment also suffered change. Game, formerly plentiful in the forests, was now being killed more effectively by the weapons the Europeans brought to the trading table. Hence, wildlife populations declined significantly. Bull's idea that neither pestilence nor war were major factors was ill advised. In fact, Indians within the lowcountry were decimated through disease, warfare, and slavery. Smallpox, whooping cough, measles, influenza and alcoholism were imported from Europe while malaria and yellow fever came from Africa (Weir 1983:26). War was also an element in their demise, contributing to smaller numbers over time. Finally, the spread of Indian slavery was causative. Weir (1983:26) states that South Carolinians were <u>the</u> Indian slave traders of the North American continent. In 1708, Indian slaves composed one-third of the slave population. Clearly, slavery was a contributing factor to the disappearance of Native American groups.

An account written by Lawson and quoted in Waddell (1980), indicates that in one instance, the Sewee Indians made an attempt to break out of the disastrous economic cycle set in place by the Carolina traders. The Sewees' observed that the English ships would always follow the same navigational path to port:

> *the craftiest of them had observed, that the Ships came always in at one Place, which made them very confident that Way was the exact Road to England; and seeing so many ships from thence, they believ'd it could not be far thither, esteeming the English that were among them, no better than Cheats, and thought, if they could carry the Skins and Furs they got, themselves to England, which were inhabited with a better Sort of People than those sent amongst them, that then they should purchase twenty times the Value for every Pelt they sold Abroad. The intended Barter was exceedingly well approv'd of, and after a general Consultation of the ablest Heads amonst them, it was, Nemine Contradicente, agreed upon..*

The plan was executed with the Sewee's launching a small navy manned by the young and able. Ignominiously, the winds did not allow a safe passage. Their crafts were overturned by the seas and those who weren't drowned were rescued from the water by Englishmen who sold the survivors into slavery.

By 1715, only the Sewee Indians were left between Charleston and the Santee River and this community numbered 57 individuals. The Yemassee Indian War of the same year would mark the closing act of this era. While the area around Beaufort and Edisto were initially impacted by fighting, the war moved northward. Four hundred colonists lost their lives; homes, produce and livestock were also lost. At the close of the war, the remaining Sewee, 22 men and 40 women and children, were captured and probably sold into slavery (Anderson and Logan 1981:39).

Colonial Period

The European settlement of Charleston and Berkeley counties and the subsequent history of the study area is tied to the successes and failures of Charleston and the lowcountry's plantation economy. Settlement of the region was first advanced under the Lord Proprietors, several of whom were also engaged in the Barbadian plantation system and the African slave trade. Hence colonial South Carolina was a product of the plantation from the onset, and was frequently regarded as the northernmost outpost of the Caribbean. The social system envisioned by the Lord Proprietors was one which meshed plantation dynamics with English nobility. While this system was never implemented as rigidly as the Proprietor's "Grand Model" proposed, the combination of slavery and the English class system influenced and structured the social dynamics of the Carolinas in the early colonial period.

As the major port of southern Carolina, Charleston quickly ascended to a position of political, religious, and social dominance within the region. The hinterlands of early Charleston were planted by families who were more residents of the city than of the outlying plantations which created their fortunes. Overseers took the place of absentee landlords in the management of many of the early plantations (Espenshade and Roberts 1991:19). The labor pool early on was composed of both Indian and African-American slaves. As the eighteenth century progressed, Africans became the primary source of labor. The increase in their population caused a visitor in 1737 to remark that "Carolina looks more like a negro country than a country settled by white people" (in Wood 1974:132-133). The slave population of Carolina increased from 1,500 individuals in 1670 to 4,100 in 1710 to 20,000 in 1730 (Weir 1983:145), and Carolina obtained a black majority by the early 1700s (Wood 1974:149). This exponential growth ended in 1741 when a prohibitive duty on new slave imports was levied after the Stono Rebellion.

While Charleston acted as the hub of settlement within the lowcountry, settlement also spread into the surrounding hinterland as the plantation economy expanded outward and solidified. With the end of the Indian trade and the beginning of rice production, the inland waterways became the chief method of conveying rice to market to be shipped to Europe. Rogers (1989:9) notes that colonial land policies were created in the 1700s which were conducive to the formation of plantations. First, the crown decided to honor patents for landgraves and caciques (orders of nobility) in the 1730s. This translated into large tracts called baronies being placed in the hands of single individuals. The headright system was also used to promote plantation growth. A headright of fifty acres was allowed for each slave brought into the colony. Those individuals able to purchase large numbers of slaves were thus rewarded with land acquisitions.

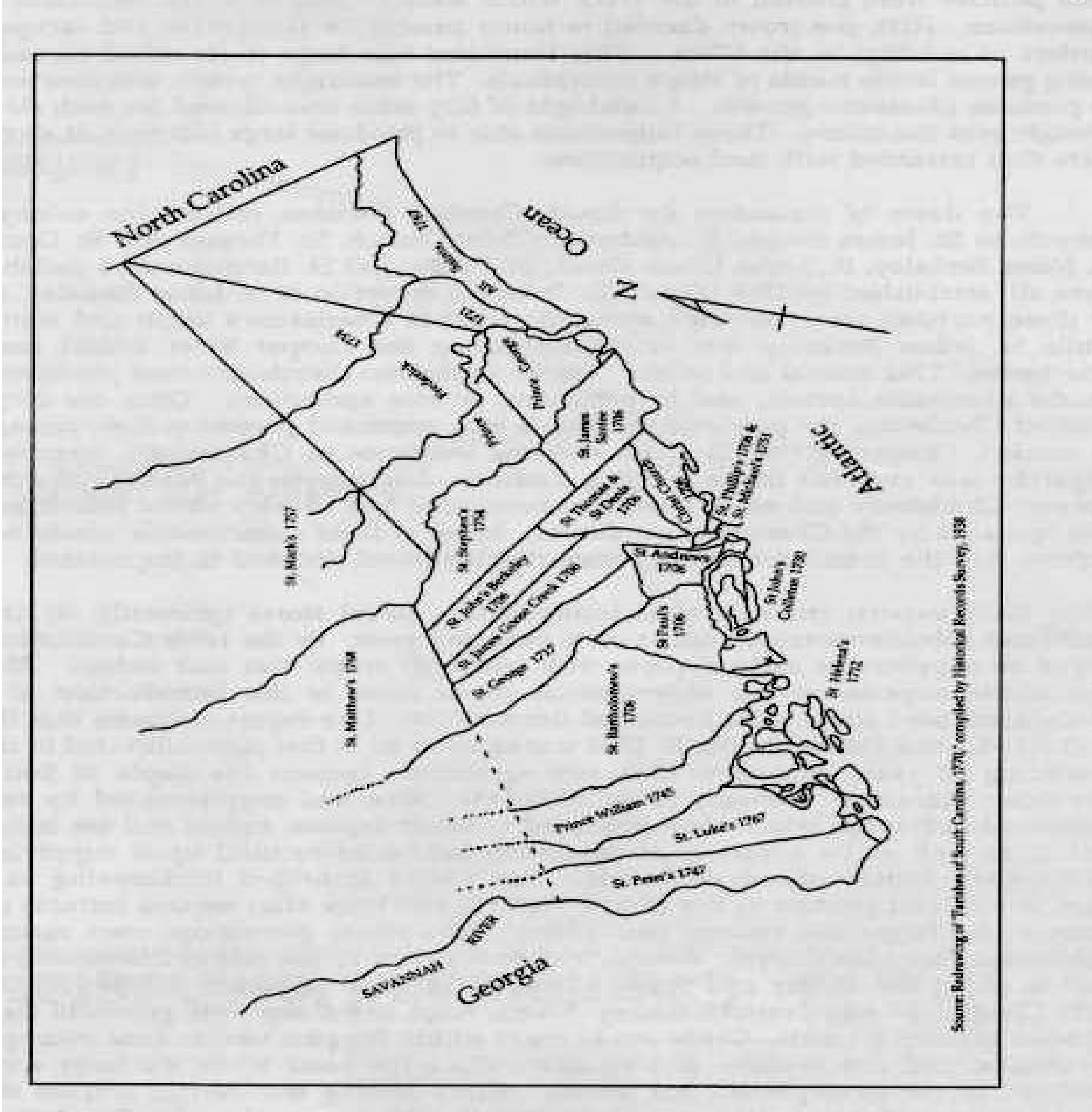
The dates of formation for South Carolina parishes reflects the colony's growth, as St. James Santee, St. Andrews, Christ Church, St. Thomas and St. Denis, St. Johns Berkeley, St. James Goose Creek, St. Paul's, and St. Bartholomews parishes were all established by 1706 (Figure 3). With the exception of St. Johns Berkeley, all of these parishes were situated along the coast to Charleston's north and south, while St. Johns Berkeley was established along the Cooper River inland from Charleston. This coastal and inland riverine settlement distribution was predicated on the plantation system, and in particular, on rice agriculture. Once the crops reached Charleston, the powerful merchants took command preparing their passage to market. Rogers

(1989:12) states that the influence of Charleston's merchant oligarchy was even felt in the outlying parishes. Cainhoy on the Wando, Monck's Corner, Childsbury and other satellite communities had country stores established and operated by the Charleston merchants. Many of these communities would not survive into the nineteenth century once riverine travel declined in importance.

Early exports from Carolina included furs, naval stores (primarily tar and pitch) and subsistence crops such as corn, peas, and meat. By the 1690s Carolina had begun to supplement these exports with two cash crops: rice and indigo. Rice agriculture experienced an experimental phase prior to the introduction of a Madagascar seed strain, then flourished dramatically. One expert estimates that the land cleared and planted in rice in 1730 was equal to all of that land cultivated in the preceding 40 years, and after 1720, rice agriculture became the staple of South Carolina's plantation economy (Weir 1983:145). Rice was supplemented by two additional cash crops which were produced in lesser degrees; indigo and sea island cotton, as well as by a variety of plantation industries focused upon supplying Charleston's active construction trade. One source identified brickmaking as a profitable second product to rice (Irving 1969:11), and brick kilns became features on many of the larger low country plantations. Brick kilns/ plantations were mainly distributed along the Cooper, Wando, and Back Rivers to the east of Charleston, as well as along the Ashley and Stono Rivers to the west. Another industry of the early Carolinians was livestock raising. Cattle, hogs, and sheep were grown in their separate grazing grounds. Cattle would graze within the pine forests, cane swamps, savannahs, and dry marshes and estuaries along the coast while the hogs were confined to the swamplands and forests. Sheep raising was carried out on the coastal plain. Cattle raising would decline in importance after the Revolution, livestock raising in general, however, continued into the nineteenth century. Anderson and Logan (1981:39) suggest as this particular industry was carried out in a separate ecological niche from rice agriculture, it was thus compatible to the growth of the major cash crop. Hence it was able to survive through time.

The naval stores industry, and later the timber industry, provides a long-lived corollary to the plantations within the social economy of the region. The production of commodities such as tar, pitch, turpentine, and rosin from longleaf pine for the construction and maintenance of naval vessels was a critical industry of Colonial and nineteenth-century South Carolina. Naval stores production peaked in the late nineteenth century, but had virtually disappeared by the 1920s with the advent of steam and diesel vessels (Harmon and Snedeker

Figure 3. 1770 parish divisions of the lowcountry



1988). Tar kilns are only one among various physical components that may have survived this industry including gum boxing stands, pitch production basins, distilling sites, overland wagon and railroad transportation networks, and river landing-wharf-dock facilities used exclusively for naval stores shipping (Robinson 1988:1-3).

Tar kilns are, by far, the most widespread recognizable components of the wood naval industry in the southeast. Tar kilns are represented by the low mounds that remain from the extraction of tar by reducing earth-covered wood piles with a slow smoldering fire. Tar kilns were made by stacking cut sticks of dead pine or lightwood at an angle facing the center and then covering such with dirt or clay. The wood pile was then lit at the top and covered to allow the gum to flow from the wood outward to conduits that directed it to pits, barrels, or iron pots set into collection pits. The boiling of tar to produce pitch was often conducted in close association with tar extraction, in clay-lined basins or kettles next to the tar kiln (Robinson 1988:3-8). The construction and tending of the tar kiln and pitch pots was a long arduous process that might have also involved the temporary quartering or stationing of workers nearby, possibly near the tar kiln production site, but generally such sites were short-term use areas not accompanied by associated habitations. Tar kiln sites are thus generally devoid of artifacts, and the extensive testing of a tar kiln site in the Francis Marion National Forest only produced 2 cut nails (Hart 1986:29-30). However, as Harmon and Snedeker (1988:6) note, additional excavation outside kiln perimeters could yield artifacts such as barrel fragments, hardware associated with draft animals and wagons, and perhaps limited habitation refuse (ie. food containers, dishes, glasses, food refuse, etc.).

Based on past survey data from South Carolina and North

Carolina, tar kilns are generally found in clusters of 2 to 3 frequently located adjacent to old roadbeds and waterways. Kiln sites usually contain the following elements: a circular mound 3 to 20 meters in diameter and 30 centimeters to 1 meter high, with a central depression 1 to 11 meters in diameter and 15 to 60 centimeters deep. The kiln is usually surrounded by a ring trench 75 centimeters to 1.5 meters wide and 35 to 65 centimeters deep. Close to the kiln ring trench is a circular or less commonly a rectangular shaped collection pit 1 to 1.5 meters in diameter and 30 to 60 centimeters deep (Harmon and Snedeker 1988:4). Kiln mounds are composed primarily of soil, with lesser amounts of charcoal left after burning. The central depression probably resulted as a combination of the thinner dirt mantle that was put on after ignition and more intense consumption of the fuel resulting in a greater degree of settling. The ring trench may have been a secondary effect of using the fill to raise the platform of the kiln and cover thin areas of the dirt mantle prior to and during firing (Harmon and Snedeker 1988:5-6).

Post-Revolutionary War

The South Carolina coastal region played an important role in the Revolutionary War and the area east of Charleston gained its current name from the exploits of the American General Francis Marion, nicknamed the "Swamp Fox" and widely recognized as the father of guerrilla warfare (Gardner 1972). Marion secured his forces within the swampy regions surrounding Charleston, and from there launched attacks on the British, effectively disrupting their land-based supply lines for much of the war. Following the war, the production of naval stores, rice, and indigo declined in response to the loss of British tariffs supporting the production of these staples. Anderson and Logan (1981:44) also note that cotton gained favor as a cash crop during this time period, since flooding along the Santee River had ruined several rice harvests and fields. Thus planters in St. Stephen's Parish began to experiment with cotton agriculture in the 1790s.

Rice agriculture enjoyed a resurgence with the introduction of tidal rice culture. Tidal rice agriculture utilized the tidal flow of inland rivers to flood and drain rice fields, and the dikes surrounding these fields protected against flood damage. While tidal rice agriculture was labor-intensive, both during the construction of dikes and ponds and in the care and harvest of rice plants, it yielded enormous profits to those with the capacity to afford it, and hence engendered a new era in plantation agriculture with fewer, larger, plantations established along major rivers. The requisite of tidal flow compelled planters to establish their operations at a distance of less than 15 to 18 miles from the coast (Hilliard 1975:57).

Civil War and Later

On the eve of the Civil War, the lowcountry featured a plantation economy in which rice plantations were the most profitable and noted feature, but which also presented smaller inland cotton plantations, subsistence farms, and industrial plantations and kiln sites. While the settlement system of this economy was predominantly rural, small "summer" settlements such as Cainhoy, Cordesville, Gravel Hill, Honey Hill, McClellanville, and Spring Hill were also found within the region. As several of these names suggest, these settlements were located primarily along the sand hills of the inner Coastal Plain, providing some elevation above the surrounding landscape and hence an ameliorated summer climate. Despite the existence of subsistence farms, rural communities, and industrial sites, the culture of the lowcountry was still dominated by the plantation economy, and hence the conclusion of the war and the enforced abolition of slavery precipitated dramatic change within lowcountry society. Rice agriculture suffered the most from the war, and was also impacted by its establishment in Louisiana and Texas, where soils were firm enough to withstand mechanized cultivation. As the agricultural economy of the region declined, settlement also decreased. By the late 1800s, the region supported two sets of commercial enterprise: phosphate mining and timbering. What remnants were left of the plantation economy continued through the preservation of plantation estates by wealthy northerners as winter homes. The twentieth century witnessed a greatly diminished rural settlement focused upon subsistence and truck farming and on employment within the timber industry.

IV. Project Overview and Objectives

Although sophisticated predictive modelling efforts are relatively new to archaeology, there has always been a strong interest in the profession for describing relationships between variables of the natural and built environments and archaeological site locations. This concern was originally subsumed under the rubric of settlement pattern studies (see Trigger 1968; Willey 1953). In general, these first attempts were rather straight-forward pattern recognition studies, comparing and contrasting associations between particular environmental variables, or micro-environmental zones, and the sites of specific culture historic periods. During the 1970s the need for more rigorous and statistically oriented analyses was recognized and models were developed from within the discipline, such as Site-Catchment Analysis (Vita-Finzi 1969; Vita-Finzi and Higgs 1970), and also borrowed from other fields, most significantly from Geography (Chorley and Haggett 1967; Hodder and Orton 1976; Haggett 1965; Haggett et al. 1977). Early successes in advancing our understanding of site locational patterning through the application of these new methods (Flannery 1976; Gummerman 1971; Roper 1979; Plog 1974) were later received with far less enthusiasm as the enormity of the task of mapping and controlling environmental variables in large archaeological data bases became evident. These limitations were felt earlier in the discipline of Geography where much of the pioneering work in developing locational models took place, and during the 1980s great progress was made in computer automating these measurement and analysis functions. Today, this data base management system is referred to as GIS, or Geographic Information Systems (Kvamme 1989). In Kvamme=s (1989:139) words, GIS provides a basis for large-scale @manipulation, analysis, storage, capture, retrieval, and display of data that can be referenced to geographic locations.?

GIS analysis is an ideal tool once data bases are available, but unfortunately these data bases are extremely expensive to generate due to the need to digitize the locations and distributions of relevant environmental variables (ie. soil types, wetlands, stream ranks, etc.). A GIS data base at the regional scale entails an extremely labor intensive effort to build and also requires powerful computer hardware capabilities not always available to researchers. There is also a fairly lengthy learning curve for working with the software. As a consequence, it is not always possible or feasible to conduct GIS analysis. This is the case with the Charleston Harbor project, where only a geographically limited GIS data base is available. The challenge we were faced with in developing a predictive model for this project was determining what methods and approaches were best suited for conducting a large regional scale study without the aid of computer automated GIS mapping capabilities.

A common theme of site locational modeling, whether subsumed under a GIS rubric (Brandt et al. 1992; Brown and Rubin 1982; Hasenstab 1983; Judge and Sebastian 1988; Kholer and Parker 1986; Kvamme 1986, 1989; Kvamme and Kohler 1988; Parker et al. 1985; Scurry 1989; Zubrow 1987) or some other statistical approach (Gummerman 1971; Roper 1979; Schermer and Tiffany 1985; Vita-Finzi and Higgs 1970), is the comparison between the environmental variable states associated with archaeological site locations and those derived from a representative sample of the larger study region (ie. non-site locations). Those variables or variable states that are disproportionally represented in the site sample are assumed to provide utility in predicting archaeological site location. In GIS studies the interaction of these variables of high predictive value can be rigorously measured through the application of such statistical techniques as logistical regression analysis or simulation modeling to produce polygons of site potential with rather definite geographic boundaries.

We considered it imperative, then, that our program for the Charleston Harbor Project identify some basis for relating generalized environmental patterning with archaeological site locational patterning and to develop some basis for rigorously mapping this relationship through the construction of polygons of ranked archaeological site potential. It was not clear at the outset of the project, though, how this might be accomplished. Large scale predictive models for site location had not yet been developed for any region in South Carolina. The first stage of the investigation was necessarily exploratory, as we did not fully comprehend which environmental variables would be relevant to the task, nor did we fully know the condition and limitations of the archaeological data base that we would be able to use to build the model. An outcome of the first stage of investigation was a clear picture of the methods and approaches that would be most suitable to this end. The second stage of the study was concerned with implementing this methodology and producing a site locational predictive model. An overview of the methods and organization of these two stages of the project is presented below.

Stage I Study

The Stage I study was organized into four phases of investigation. These included: (1) sample selection, (2) definition of variables and data collection, (3) statistical pattern analysis, and (4) model assessment. The organization of each of these stages will be described below.

Sample Selection

The greater Charleston Harbor watershed encompasses Berkeley, Charleston, and Dorchester counties. The State Site Files housed at the South Carolina Institute of Archaeology and Anthropology (SCIAA) in Columbia contain information on over 4,000 sites from these three counties. Given the scope of the study and its objectives, it was concluded rather quickly that the entire data base would not be suitable. First of all, the data available for each site are quite uneven, depending upon the age of the site form and the experience of the individual filing the report. Site forms can be filled out by individuals without any professional background in archaeology. Moreover, the accuracy and level of sophistication evident in the forms has increased significantly over the last decade with the intensified input of professional archaeologists. Second, it was felt that the sample should reflect an unbiased and fairly representative picture of the archaeology of the project area. Representativeness is not always a concern in developing site predictive models because the control on site patterning is supplied by random or systematic sampling of non-site areas. However, in this instance, we wanted the site sample to be amenable to comparative analysis of settlement patterns between culture historic periods. Also, we wanted to get a fairly accurate and representative picture of settlement types, site sizes, site densities, and the relative proportion of significant sites.

Taking these factors into consideration, it was concluded that the sample should ideally consist of those sites identified over the past decade as a result of intensive surveys conducted under the format of cultural resource compliance projects. These surveys generally tend to be characterized by consistent site discovery and boundary definition methodologies that were deployed at a level of intensity sufficient to provide a firm basis for comparative studies. Modern intensive surveys in the state cover tracts of land with shovel tests spaced at 30 or 60 meter intervals. The soil from each shovel test, which is approximately 1 foot in diameter, is screened through 1/4 inch mesh hardware cloth and artifacts caught by the screen are used to identify and define the location of archaeological sites, most of which are not observable on the ground surface due to vegetation and leaf litter. Once sites are discovered using this methodology, their boundaries are defined through additional shovel tests placed at shorter intervals (ie. 10 or 15 meters). These methodologies establish a base-line standard for comparative purposes that would otherwise not exist if the entire sample from the site files were to be considered.

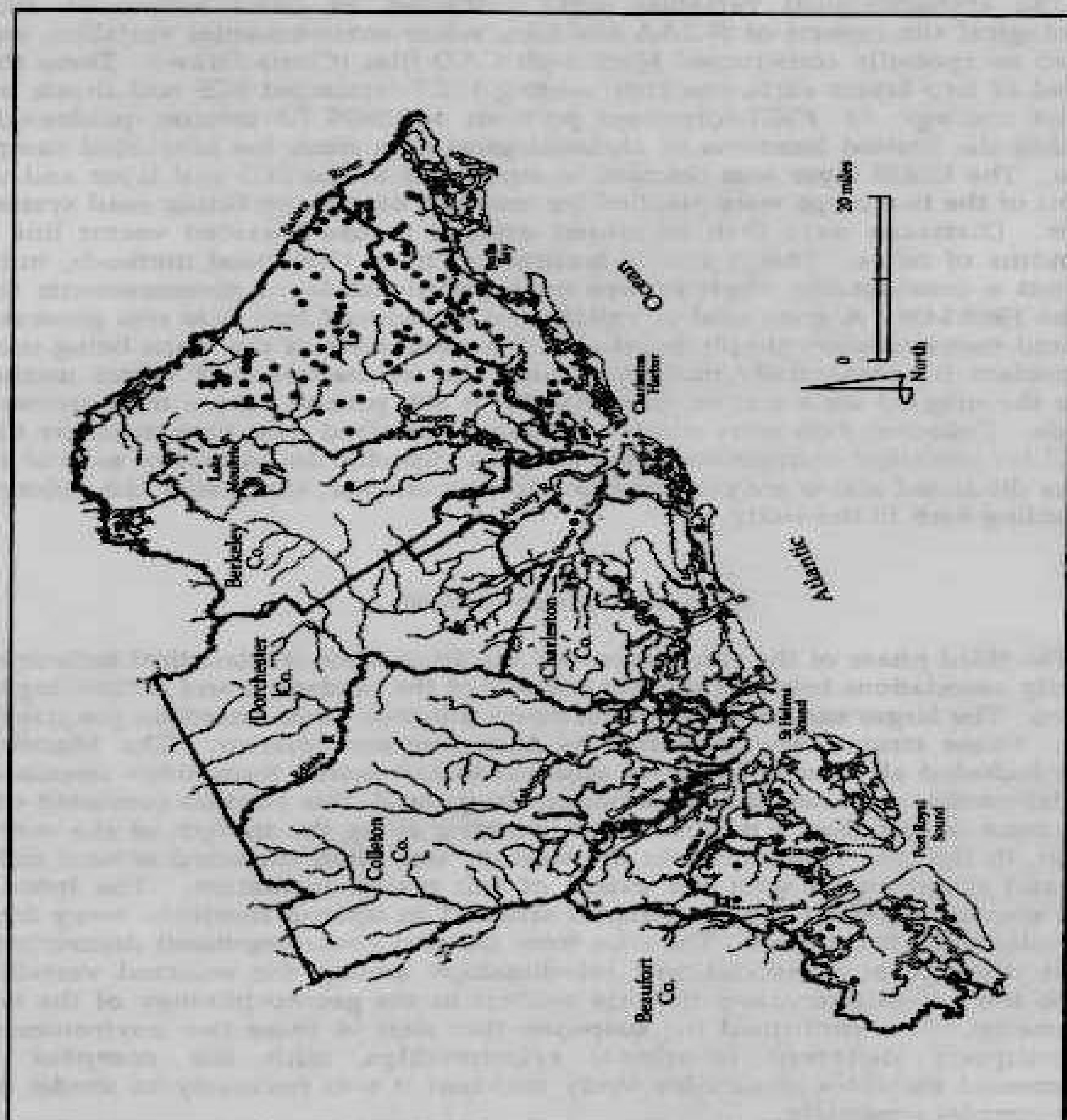
A final concern was sample size. We did not want to limit the sample too severely by applying the requirement of modern survey methodology. Consequently we conducted a review of the available compliance reports from the tri-county area to ascertain if this would be an unduly harsh constraint. A total of 882 sites were tabulated from modern survey projects, 423 from Berkeley County and 459 from Charleston County. None were found for Dorchester County, where very little compliance archaeology has been conducted. This seemed like an adequate sample, but we decided to expand the data base to include modern survey projects from Beaufort and Colleton counties as well. This increased the overall sample to 1,208 sites from 149 projects. A map of project locations is illustrated in Figure 4 and a listing of these projects is presented as Appendix A in the back of this report. As can be seen, the vast majority of survey projects in Beaufort and Charleston County are situated on the coastal fringe and tidal creeks, where the bulk of compliance-related development has occurred. The Berkeley County, sample, by contrast, is principally distributed across interior settings of the Francis Marion National Forest, where Hugo-salvage operations entailed the clearing of large tracts of land throughout the Forest in the early 1990s. These differences tend to balance each other out and we are on fairly firm ground in assuming that this sample represents an unbiased and fairly representative sample of the greater Charleston Harbor watershed.

Definition of Variables and Data Collection

The next phase of the study was to define the relevant archaeological and environmental variables and to devise a methodology to measure them. The archaeological variables were designed to derive simple site functional typologies (ie. homestead, plantation, prehistoric village, prehistoric camp site, etc.) and to characterize the archaeological data along a number of different dimensions. These included: (1) site size, (2) artifact density, (3) the size of individual occupations within the site (ie. prehistoric component, historic component, etc.), (4) the relative size and contribution of specific occupational periods within individual sites, and (5) the density of artifacts by occupational period. This program of analysis was instituted so that a number of factors relating to site significance and settlement pattern analysis could be monitored. A listing of the culture historic representation of the site sample by project is presented as Appendix B at the back of this report.

Environmental variables for the study focused on soil and stream characteristics. The soil data collected for each site included: (1) SCS soil type, (2) soil hydrologic group, (3) distance to nearest soil hydrologic group interface, and (4) distances to the nearest interfaces of all other soil hydrologic groups. Soil interface data figure prominently in site locational strategies along the South Carolina coast (Scurry 1989; Cable et al. 1995) and these data provided a strong foundation for the modelling efforts of this project. Streams were ranked according to the Strahler (1977) method of drainage network ordering and distances were measured from sites to each of the nearest ranked streams on a scale of 1 to 6. Distances to major roads were also recorded, primarily to examine the impact of transportation arteries on historic site location. Distance themes of this sort are a common feature of GIS studies and other site locational investigations.

Figure 4. Map of Stage I project locations



The archaeological variables were extracted, or hand measured, from archaeological site reports or SCIAA site files, while environmental variables were recorded on specially constructed MacIntosh CAD files (Claris Draw). These files consisted of two layers each, one representing PICT-formatted SCS soil sheets and the other tracings of PICT-formatted portions of USGS 7.5 minute quadrangles containing the plotted locations of archaeological sites from the identified sample projects. The USGS layer was rescaled to equal that of the SCS soil layer and the positions of the two maps were justified for matched overlay by fitting road systems together. Distances were then measured using a mouse-operated vector line in thousandths of miles. This is not as accurate as most GIS-based methods, but it represents a considerable improvement over traditional hand measurements (see Kvamme 1989:143). A great deal of variation is introduced into data sets generated from hand measurements simply because of the small scale of the maps being used. This problem is substantially mitigated using the mouse-operated vector method because the original scale can be enlarged 400 to 800 percent before measurements are made. Collected data were entered onto computerized data base manager files (EXCEL) for statistical manipulation and analysis. Specific definitions of each of the variables discussed above are presented in the next chapter, along with the rationale for including each in the study.

Statistical Pattern Analysis

The third phase of the study involved the application of statistical techniques to identify associations between specific features of the landscape and archaeological site types. The larger sample was broken down into two strata based on geographic setting. These strata were identified as *Maritime* and *Interior*. The Maritime stratum included all sample locations adjacent to salt marsh formations associated with tidal creeks, estuaries and open ocean. In general, this stratum consisted of a narrow zone of less than 1 mile in width running along the margin of the ocean. However, in the case of tidal creeks the stratum was often extended several miles inland and coterminous with the extent of salt marsh formation. The Interior stratum encompassed all project samples situated in upland locations away from coastal salt marsh formations. The sites from the two strata produced distinctively different distance and associational relationships among the selected variables owing to the obvious contrasts that are evident in the geomorphology of the two environments. This confirmed the suspicion that sites in these two environments have uniquely different locational relationships with the complex of environmental variables chosen for study and that it was necessary to model the two site samples separately.

Model Assessment

The final phase of the Stage I study consisted of an evaluation of the utility of generating predictive models of site location with the site sample and the set of variables chosen for analysis and interpretation. For this purpose three project locations each from the Maritime and Interior strata were selected for more intensive study. Systematic grids of 0.1 mile (ie. 528 ft) intervals were established to extract a @non-site? or control point sample of environmental distances to contrast against the site sample from these projects. Figures 5 and 6 illustrate the archaeological site locations and control point sampling grid for one of these areas, Pinckney Island in Beaufort County.

Initial statistical analysis of environmental and archaeological site locational associations indicated that a number of variables were significantly contributing to site location and that no single variable could effectively describe the relationship. Consequently, we were obliged to consider a range of multivariate statistical approaches to model site location. Since we wanted to devise a model that could predict the most probable locations for archaeological sites on a landscape we found that the standard method referred to as *multiple regression* (Ott 1984:391) could be most effectively used to accomplish this objective. This is because multiple regression models are linear equations that solve for a specified variable, the predicted variable, based on its relationship with a number of correlated variables referred to as predictor variables. Once this relationship is empirically described on a data base where all values are known and measured, the derived equation can be used to predict unknown values of the desired variable, in this case some expression of archaeological site locational sensitivity. The logistic regression models used in many GIS analyses (see Kvamme 1989) are essentially spatial expressions of multiple regression models.

The predicted variable we chose to initially work with was distance to nearest archaeological site. This variable and each of the specified environmental and cultural predictor variables were measured for all control points and site locations within the six study areas. The derived equations explained between 20 and 40 percent of the variability contained within the predictor variables. Although these were not particularly high multiple correlation values (R^2), the accompanying F-test and t-test results indicated that they nevertheless described significant variation with respect to the predicted variable. Moreover, when the predicted values for the control points were plotted across each study area using standard contouring algorithms, there also appeared to be a strong spatial relationship between the distribution of predicted values and the locations of archaeological sites. These were promising results, suggesting that more powerful equations could be generated by increasing the control point samples and incorporating a number of derived variables (ratios) from the raw data.

Figure 5. Map of Pinckney Island soil drainage groups showing site location

Please contact the SC DHEC-Office of Ocean and Coastal Resource Management, 1362 McMillan Avenue, Suite 400, Charleston, SC 29405 for information on this figure.

Figure 6. Map of Pinckney Island soil drainage groups showing sample grid layout

Please contact the SC DHEC-Office of Ocean and Coastal Resource Management, 1362 McMillan Avenue, Suite 400, Charleston, SC 29405 for information on this figure.

The immediate utility of a model structured in this way is that it provides an easily implemented and understood procedure for drawing archaeological site sensitivity polygons without the need for the powerful and expensive computer equipment used to generate GIS models. Within any unsurveyed tract in the greater Charleston watershed polygons of this sort can be drawn simply by measuring the set of predictor variables in a 0.1 mile interval grid node sample and calculating the regressed value for each node using the model equations.

Stage II Study

The Stage II study was aimed at dove-tailing and expanding two supplemental investigations undertaken in the Stage I program. One study focused on expanding the control point data base to include a larger proportion of the original project sample. The other was concerned with providing an additional level of critical review of the model by conducting independent validation of the regression models generated from the expanded control point data base. This was done by evaluating the goodness of fit between the models and a selection of more recent, compliance-related intensive surveys conducted in the Charleston Harbor watershed. The structure and scope of each of these studies are discussed below.

Expansion of the Control Point Sample

As is true of all statistical models, the larger the data base the greater the accuracy and precision of the resulting equations, providing that the data have been generated with sufficient rigor and control. Only a relatively small sample of the potential project locations was subjected to this kind of analysis during the Stage I investigation. The preliminary work indicated that a 0.1 mile spacing of control points across survey areas would increase the size of the data base by a factor 500 percent. As budgetary constraints were a concern, it was concluded that the entire Stage I data base could not be used and it would be necessary to merely sample the available set of projects. Since we were concerned with developing models to separately describe site locational variation in the interior uplands and on the maritime strand along the coast we stratified the sample on this basis. For the Interior Sample we included all surveyed areas of sufficient size within the Cainhoy (Williams et al. 1992a), Huger (Williams et al. 1992b), and St. Stephens (Williams et al. 1993a) divisions of the Hurricane Hugo Salvage Survey on the Francis Marion National Forest (Figure 7). This sample ultimately consisted of data generated from 1,057 control points and 196 archaeological sites. The Maritime Sample was drawn from five surveys conducted in and around Mount Pleasant, SC in Charleston County (Figure 8). These included the Charleston National Golf Course (Brockington et al. 1987), Hobcaw Plantation (Brockington 1987), Palmetto Fort (Espenshade and Poplin 1988), Parker Island (Southerlin et al. 1988), and Seaside Farms (Adams and Trinkley 1993). The Maritime Sample consisted of 491 control points and 76 archaeological sites.

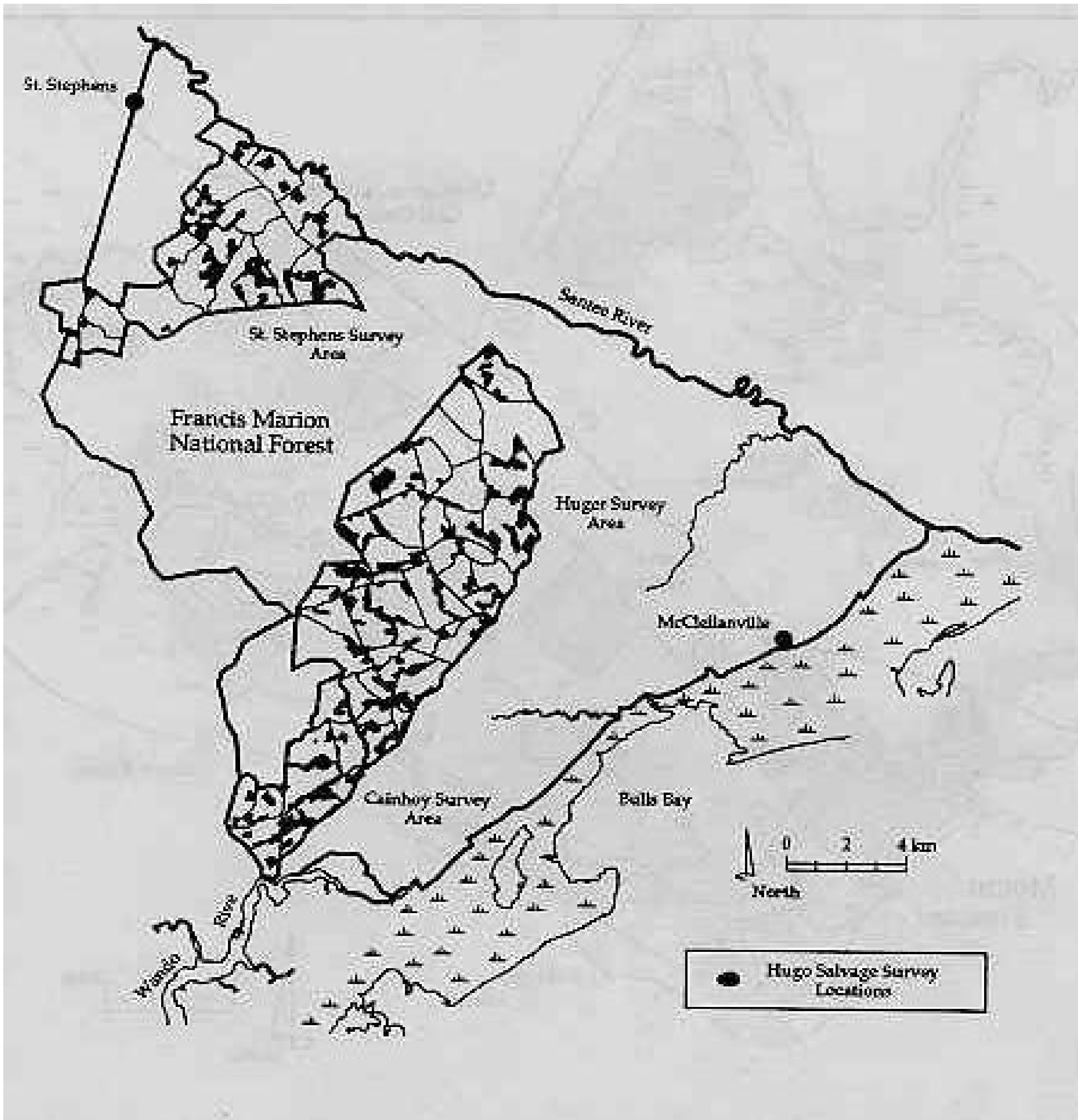


Figure 7. Map of Stage II Interior Sample loci

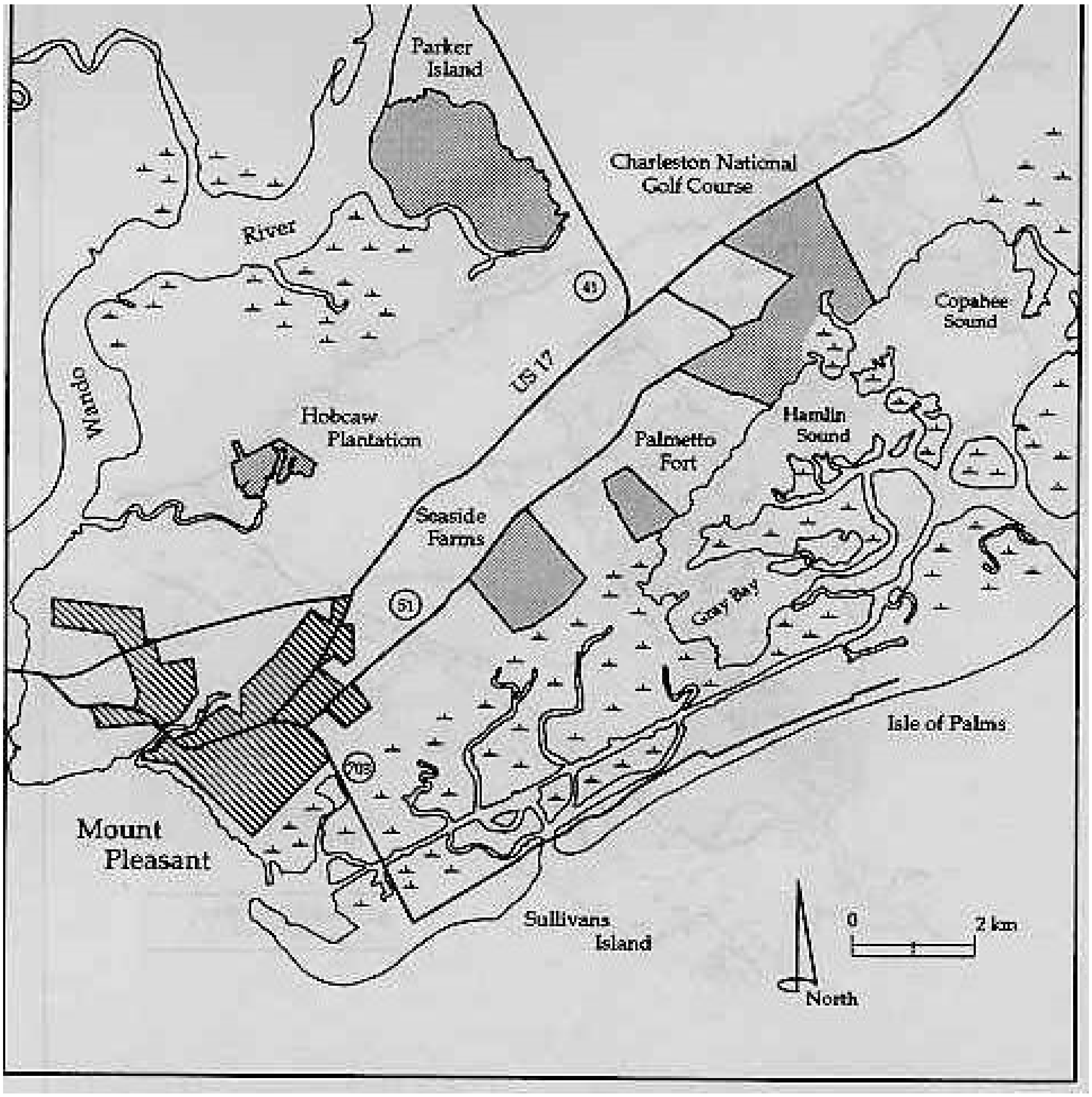


Figure 8. Map of Stage II Maritime Sample loci

Validation

At the outset of the project the State Historic Preservation Office (SHPO) expressed a desire for the predictive modelling effort to be @field? tested to further evaluate its validity and accuracy. It was determined that the most expedient and also effective approach to validation would be to test the model against independent data derived from surveys of comparable site discovery methodology that were not incorporated into the Stage II sample. Testing of the Interior model was accomplished using data from three locations in the Bethera and Santee divisions of the Hugo Salvage Survey (Williams et al. 1992c, 1993b), while the Maritime model was tested using the contiguous survey areas of the Sewee Fire and Salt Pond tracts (Cable et al. 1995; Gardner 1992) and the South Tibwin tract (Cable et al. 1995), all of which are located on the Francis Marion National Forest. The three Interior tests consisted of a total of 603 control points, while the Maritime tests required the recording of an additional 361 control points.

Concluding Remarks

Although our initial goals were to develop predictive models for major occupation periods and site functional types, this proved to be too ambitious an undertaking given the time and budgetary constraints of the project. What will be described in the remainder of this report are very generalized models for archaeological sites as a whole. Hopefully in the future there will be opportunities to continue this research so that more detailed and specific locational models can be developed. Such an enterprise would prove invaluable for purely theoretical archaeological research, but it is our hunch that this research would also refine and improve the locational models offered here and in this way supply developers and planners with more specific data on site distributions.

V. Description and Measurement of Variables

This chapter describes the methodology used to select and define analysis variables for the predictive model. The discussion will include the reasoning behind the variable selection as well as the methods devised to record and measure each variable. The spatial variables described in this chapter were generated only after a protracted period of pre-testing and evaluation during the Stage I investigation. For the sake of brevity, however, the steps in this process are not presented here. The discussion primarily focuses on the final derivation of variables used in the predictive model, or in some other aspect of the final analysis. The chapter is divided into two parts. The first part briefly discusses the archaeological variable program that was initiated in the Stage I investigation, but discontinued so that full attention could be given to developing generalized predictive models. The second part describes the spatial variables that were used in constructing the predictive model.

Archaeological Variables

Time and budgetary constraints ultimately forced us to construct a site predictive model with no other site data than location, as has been done, for instance, by Brandt et al. (1992). It would seem that a much greater amount of information could be supplied to planners and to cultural resource management agencies if a range of archaeological site characteristics could also be considered in the process of modelling (see Brown and Rubin 1982; Parker et al. 1986; Zubrow 1988). At the outset of Stage I investigations we began to record some of these site characteristics that we thought might be instructive in this regard. These included variables that would describe aspects of the periods of occupation, cultural affiliation and function (ie. plantation, grist mill, camp site, village, etc.) of each site in the data base. The only variable that was collected for all sites, however, was site size. Site size will be used to discuss some of the general archaeological characteristics of the Charleston Harbor watershed later in this report. The other measurement programs were discontinued fairly early in the Stage I investigation and will not be further elaborated here.

Spatial Variables

Variables most commonly recorded for predictive modelling projects relate to features of the natural environment. These include geologic substrate, soil type, vegetation communities, elevation, slope, aspect, landform, soil productivity class, run-off, precipitation, temperature, and stream hydrology. Secondarily, features of the built environment have also been shown to have effects on site location, especially for historic sites in the United States. Roads, ferries, and railways represent typical cultural variables of significant impact to historic site location. Variable states can be measured as nominal, ordinal or continuous data. An example of a nominal variable would be a particular soil type, while an ordinal variable expresses a ranked relationship such as a soil drainage classification. Continuous variables are quantitative measurements of some spatial aspect of a variable, such as distance to a water source or road.

The environment of the greater Charleston Harbor area is characterized by low relief and poor drainage. These factors argue against the utility of elevation and slope data for modeling site location. Moreover precipitation patterns do not appear to pose long-term constraints on site location since the entire area is well watered and summer rainfall variation from one location to the next is fairly random.

Previous studies in the area have identified soil drainage as the primary factor affecting site location (see Brooks and Scurry 1978; Scurry 1989). Scurry (1989), in fact, conducted a GIS study on the AMOCO property within the greater Charleston Harbor area and found that a primary determinant of site location in the interior coastal plain was distance to particular soil interfaces. Specifically, he found that prehistoric sites were situated near interfaces between moderate or well-drained soils and poorly drained soils. He further surmised that this relationship was the result of locational optimization wherein sites were situated as close to resource patches (ie. poorly drained soils or swamps) as feasible, while also maintaining adequate site drainage conditions. Other ecological parameters recognized by Scurry as having some predictive value for site location were elevations over 15 feet above sea level, relatively flat terrain (slopes less than 6 %), and southwest aspects for the larger multicomponent sites. Nearness to streams was not significantly associated with site locations in this study.

A potential problem with using the AMOCO study results for modelling the larger Charleston Harbor area is that it represents a very limited sample of site types and environmental settings. The sites were primarily small, prehistoric resource extraction camps not occupied for long stays and the setting is a decidedly interior location. This means that the set of predictive variables identified may not apply to larger sites and to settings nearer major floodplains or along coastal marsh formations. Moreover, the variable of elevation would seem to be difficult to use since a large amount of elevational variation in the project area is related simply to the proximity of a location to the shore and seemingly not to specific locational pressures exerted on site location by the character of the landscape. It is likely, therefore, that this variable would create a great deal of noise in the analysis if used in an unmodified manner.

The results of the AMOCO study, and also the informal model of site locational probability used by the Forest Service on the Francis

Marion National Forest (Robert Morgan, personal communication 1995), indicate that the variables possessing the greatest universal applicability for modelling site location are soil hydrologic unit (ie. drainage ranking) and soil interface distance and these were selected as two of the primary emphases of the current study. The relationship that Scurry identified as significant was nearness to interfaces between well or moderately well-drained and poorly drained soils. It was reasoned that other interfaces might also have significance, either as a single measurement, or as a combined variable. Combined variables, in fact, could inform on a number of other aspects of the setting. For instance, if distance to all soil drainage rankings was measured for each site and for each control point, then it would be possible to define a new variable informing on the edaphic complexity surrounding a site or location. This would provide a relative measure of topographic variability that would not rely on elevation or slope, both variables of low resolution in the coastal environment. Moreover, distances to poorly drained and very poorly drained soils would identify small swamp or bay patches that otherwise might not be depicted on a USGS topographic map.

Another variable of interest to this study was proximity to streams. Although it was not proven to be useful for the AMOCO project, this project area may have been too limited in scale to test the actual predictive value of this variable. Our experience on the Francis Marion National Forest suggested that distance to streams of various ranks did have some utility in predicting the locations of certain kinds of sites, especially the larger or more permanent types. Moreover, it was felt that there might be an optimal distance at which certain kinds of sites would be found from streams of specified ranking. In other words, the relationship might not be expressly linear, but might exhibit some type of logistical drop-off curve at a regularized distance threshold.

A final variable of particular importance to historic site location was distance to main roads. This again is a variable that should not be expected to have a simple linear relationship with historic sites. If we look at a section of the 1695 Thornton-Morden map around Charleston Harbor (Figure 9) we see that the early plantations leading away from the town were situated at an optimal or intermediate distance between a main feeder road and the various tidal creeks where wet rice fields were planted. This pattern remained fairly constant throughout the eighteenth century as is nicely depicted on the James Cook map of

Figure 9. Portion of Thornton-Morden map of 1695

1773 (Figure 10), particularly along the early Georgetown Road (US 17) north of Charleston. Although the large scale maps depict a nearly equidistant positioning of the plantations between main roads and creeks, contemporary plats of the area indicate that the plantations were actually closer to the creeks. A compilation of late eighteenth century plats in the Cooper River area (Smith 1988), for instance, shows a rather regular spacing of plantations about one-third of the way between tidal creeks and main roads (Figure 11).

Figure 10. Portion of James Cook map of 1773

Figure 11. Portion of Smith (1988) compilation map of 18th century Cooper River plats

Because archaeological predictive modelling is relatively new and undeveloped in South Carolina, we wanted to maintain a certain degree of flexibility in the analysis program so that we could explore a variety of relationships. This was accomplished by recording distances to all stream ranks and all possible combinations of soil interfaces rather than exclusively focusing on only the nearest variable state (ie. distance to nearest water source, distance to nearest soil interface, etc.). In the case of the soil interface data, this procedure also provided an opportunity to derive additional variables such as interface diversity, a measure of the degree of topographic and microenvironmental variation in a particular location. Descriptions of each of the spatial variables developed for this analysis are presented below. Spatial variables were recorded for both archaeological site locations and control points.

Soil Hydrology Variables

In forested environments of relatively low relief, perhaps the single most important variables for archaeological site locational modeling are soil characteristics (see Brandt et al. 1992; Kvamme 1989; Schermer and Tiffany 1985). Of these, the characteristic of highest predictive value in the South Carolina coastal plain appears to be soil drainage hydrology (see Brooks and Scurry 1978; Scurry 1989). The USDA Soil Conservation Service classifies soil drainage in the coastal plain according to profile coloration (Long 1974: 45). Excessively well drained and well drained soils exhibit a yellowish brown or reddish subsoil and are free of mottles to a depth of 30 inches. The yellowish and reddish coloration is due to the formation of thin iron oxide coatings on sediment particles in highly oxygenated (ie. dry) matrices. Moderately well drained soils also have yellowish brown and reddish substrates, but they are periodically wet and contain yellowish brown and gray mottles at depths of 15 to 20 inches. Somewhat poorly drained soils are wet for longer periods than moderately well drained soils and tend to have a predominance of gray mottles, indicating increased gleying. Gleying is a process whereby water ions reduce and transfer iron and is associated with wetter, more poorly drained conditions. Poorly drained and very poorly drained soils have grayish colored subsoils as a consequence of prolonged saturation. These latter two drainage ranks are commonly associated with creek bottoms, bays, and swamps, while the better drained soils occur on the tops and slopes of ridges. Each SCS soil series is classified according to this scheme and this information can be extracted from each series description.

Soil type distributions for each sampling location were classified according to the SCS system and assigned ordinal (ranked) scale values of 1 to 6 reflecting a scale of drainage ranks (Table 1). This was done for two purposes. First, the ordination provided an opportunity to numerically evaluate relative drainage conditions. Second, since different soil types may have the same drainage ranking, this method provided a more readily interpretable scheme for performing measurements. A drainage rank of 1 indicates well drained conditions, while higher values indicate gradually more poorly drained conditions. Excessively well drained and well drained soils, owing to their general scarcity in the greater Charleston Harbor watershed, were combined into a single ordinal value. In addition, salt marsh soils were assigned a value of 6 to differentiate them from freshwater swamp and bay soils. A listing of the ordinal rankings for each soil type in Berkeley and Charleston counties are presented in Tables 2 and 3. The Charleston County survey was conducted between 1954 and 1966 and as such does not reflect modern SCS classification methodology. Through conversations with SCS personnel in Columbia, SC, however, it seems that soil drainage classification has changed little in this period of time and consequently the dated nature of the survey does not prove to be an impediment to the current study.

Table 1. Ordinal scale values assigned to the SCS soil drainage classification.

Drainage Classification	Ordinal Value
Excessively Well Drained/Well Drained	1
Moderately Well Drained	2
Somewhat Poorly Drained	3
Poorly Drained	4
Very Poorly Drained	5
Salt Marsh	6

Nine variables were constructed using this drainage ordination scheme. These included:

(1) *DR0*, which represents the associated drainage rank of the soil type upon which the control point or site was situated.

(2)*CAT*, which is the drainage category of the nearest soil type interface from the control point or site. This variable is a combination of the associated drainage rank (*DR0*) of the control point or site and the rank of the nearest soil interface. Standard recording procedure involved a listing of the lowest rank and then the highest rank of the two, separated by a period. This is a categorical or nominal variable, however, rather than a continuous one as it appears. In example, if a point is situated on a soil rank of 2 and the nearest other soil type has a ranking of 4, then the *CAT* value would be 2.4. If the nearest soil type had an identical ranking to *DR0*, it was ignored, and the nearest soil type with a different ranking was used to describe the variable.

(3)*NEAR* is the distance between the control point or site and the nearest soil interface.

(4-9)*DR1, DR2, DR3, DR4, DR5,* and *DR6* represent the distances between the control point or site and the nearest soil types of each remaining rank. Distance to the associated soil type ranking (*DR0*) would be 0 and distance to the next nearest soil type ranking would correspond to the variable *NEAR.* Thus, if the nearest soil type ranking was a 3, the distance recorded for the nearest soil interface (*NEAR*) would be recorded in *DR3* as well. Likewise, if the associated soil type ranking was a value of 2, a distance of 0 would be entered in *DR2*. Distance to the remaining nearest soil rankings, then, would all be new measurements.

Table 2. Ordinal scale values for soil types in Berkeley County (Long 1974).

Soil Type	Abbreviation	Drainage Description	Rank
Bayboro loam	Ba	Very poorly drained	5
Bethera loam	Be	Poorly Drained	4
Bohicket silty clay loam	BH	Very poorly drained	5
Bonneau loamy sand, 0-2%	BoA	Moderately well drained	2
Bonneau loamy sand, 2-6%	BoB	Moderately well drained	2
Byars loam	By	Very poorly drained	5
Cainhoy fine sand, 0-6%	CaB	Somewhat excessively drained	1
Capers Association	CP	Very poorly drained	5
Caroline fine sandy loam, 2-6%	CoA	Well Drained	1
Caroline fine sandy loam, 2-6%	CoB	Well Drained	1
Chastain Association, freq. flooded	CS	Poorly Drained, Alluvial Soils	4
Chipley-Echaw Complex	Ct	Moderatley Well Drained	2
Coxville fine sandy loam	Cu	Poorly Drained	4
Craven loam, 0-2%	CvA	Moderately Well Drained	2
Craven loam, 2-6%	CvB	Moderately Well Drained	2
Duplin fine sandy loam, 0-2%	DuA	Moderately Well Drained	2
Duplin fine sandy loam, 2-6%	DuB	Moderately Well Drained	2
Goldsboro loamy sand, 0-2%	GoA	Moderately Well Drained	2
Lenoir fine sandy loam	Le	Somewhat Poorly Drained	3
Leon fine sand	Lo	Poorly Drained	4
Lucy loamy sand, 0-6%	LuB	Well Drained	1
Lynchberg fine sandy loam	Ly	Somewhat Poorly Drained	3
Meggett clay loam	Mp	Poorly Drained	4
Meggett loam	Mg	Poorly Drained	4
Norfolk loamy sand, 0-2%	NoA	Well Drained	1
Norfolk loamy sand, 2-6%	NoB	Well Drained	1
Ocilla loamy fine sand	Oc	Somewhat Poorly Drained	3
Pamlico Muck	Pa	Very Poorly Drained, depressions	5
Pantego fine sandy loam	Pe	Very Poorly Drained	5
Pickney loamy fine sand	Pk	Very poorly drained	5
Rains fine sandy loam	Ra	Poorly drained	4
Santee loam	Sa	Very Poorly Drained	5
Seagate loamy sand	Se	Somewhat Poorly Drained	3
Tawcaw Association, freq. flooded	TA	Somewhat Poorly Drained, alluvium	3
Wahee loam	Wa	Somewhat Poorly Drained	3
Witherbee fine sand	Wt	Somewhat Poorly Drained	3

Table 3. Ordinal scale values for soil types in Charleston County (Miller 1971)

Soil Type	Abbreviation	Drainage Description	Rank
Bayboro sandy clay loam	Ba	Very Poorly Drained	5
Cape Fear loam	Cf	Very Poorly Drained	5
Capers silty clay loam	Cg	Saturated Tidal Flats	6
Charleston loamy fine sand	Ch	Moderately Well Drained	2
Chastain Soils	Ck	Very Poorly Drained	5
Chipley loamy fine sand	Cm	Moderately Well Drained	2
Coastal beaches and dune land	Co	Excessively Well Drained, dunes	1
Crevasse-Dawhoo Complex, rolling	CvC	Very Poorly Drained	5
Dawhoo and Rutlege lomay fine sand	Da	Poorly Drained	4
Dunbar and Ardilla fine sandy loams, 0-2 %	DdA	Somewhat Poorly Drained	3
Edisto loamy fine sand	Ed	Somewhat Poorly Drained	3
Faceville fine sandy loam, 2 - 6 %	FvB	Well Drained	1
Hockley loamy fine sand, 0 - 2 %	HoA	Moderately Well Drained	2
Hockley loamy fine sand, 2 - 6 %	HoB	Moderately Well Drained	2
Kiawah loamy fine sand	Ka	Somewhat Poorly Drained	3
Lakeland sand, 0 - 6 %	LaB	Excessively Drained	1
Leon fine sand	Le	Somewhat Poorly Drained	3
Meggett clay loam	Me	Poorly Drained	4
Meggett loam	Mg	Poorly Drained	4
Myatt loam	My	Poorly Drained	4
Norfolk and Dothan soils, 0 - 2 %	NdA	Well Drained	1
Orangeburg loamy fine sand, 0 - 2 %	OrA	Well Drained	1
Orangeburg loamy fine sand, 2 - 6 %	OrB	Well Drained	1
Osier fine sand	Os	Very Poorly Drained	5
Pamlico muck	Pa	Very Poorly Drained	5
Portsmouth fine sandy loam	Po	Very Poorly Drained	5
Quitman loamy sand	Qu	Somewhat Poorly Drained	3
Rains sandy loam	Ra	Poorly Drained	4

Rutlege loamy fine sand	Rg	Poorly Drained	4
Rutlege-Pamlico complex	Rp	Poorly Drained	4
Santee clay loam	Sc	Very Poorly Drained	5
Santee loam	Se	Very Poorly Drained	5
Scranton loamy fine sand	Sf	Somewhat Poorly Drained	3
Seabrook loamy fine sand	Sk	Moderately Well Drained	2
Seewee Complex	Sm	Somewhat Poorly Drained	3
St. Johns fine sand	Sa	Poorly Drained	4
Stono fine sandy loam	St	Very Poorly Drained	5
Tidal marsh, firm	Tf	Tidal Marsh, Firm	6
Tidal marsh, soft	Ts	Tidal Marsh, Soft	6
Wadmalaw fine sandy loam	Wa	Poorly Drained	4
Wagram loamy fine sand, 0 - 6 %	WgB	Well Drained	1
Wando loamy fine sand, 0 - 6 %	WnB	Excessively Drained	1
Wicksburg loamy fine sand, 0 - 6%	WoB	Well Drained	1
Yonges loamy fine sand	Yo	Poorly Drained	4

As mentioned briefly in the last chapter, the method we used to measure and record these variables was to computerize sections of SCS soil sheets. Pertinent sections of the sheets were scanned and exported to a CAD program. The program we selected to use was Claris Draw because of the detailed layering, griding, rescaling and enlargement capabilities. Once converted to Claris Draw files, the mapping scale was set at the 20,000 to 1 scale of the SCS maps and actual distances between control points or sites and soil interfaces were measured using line vectors.

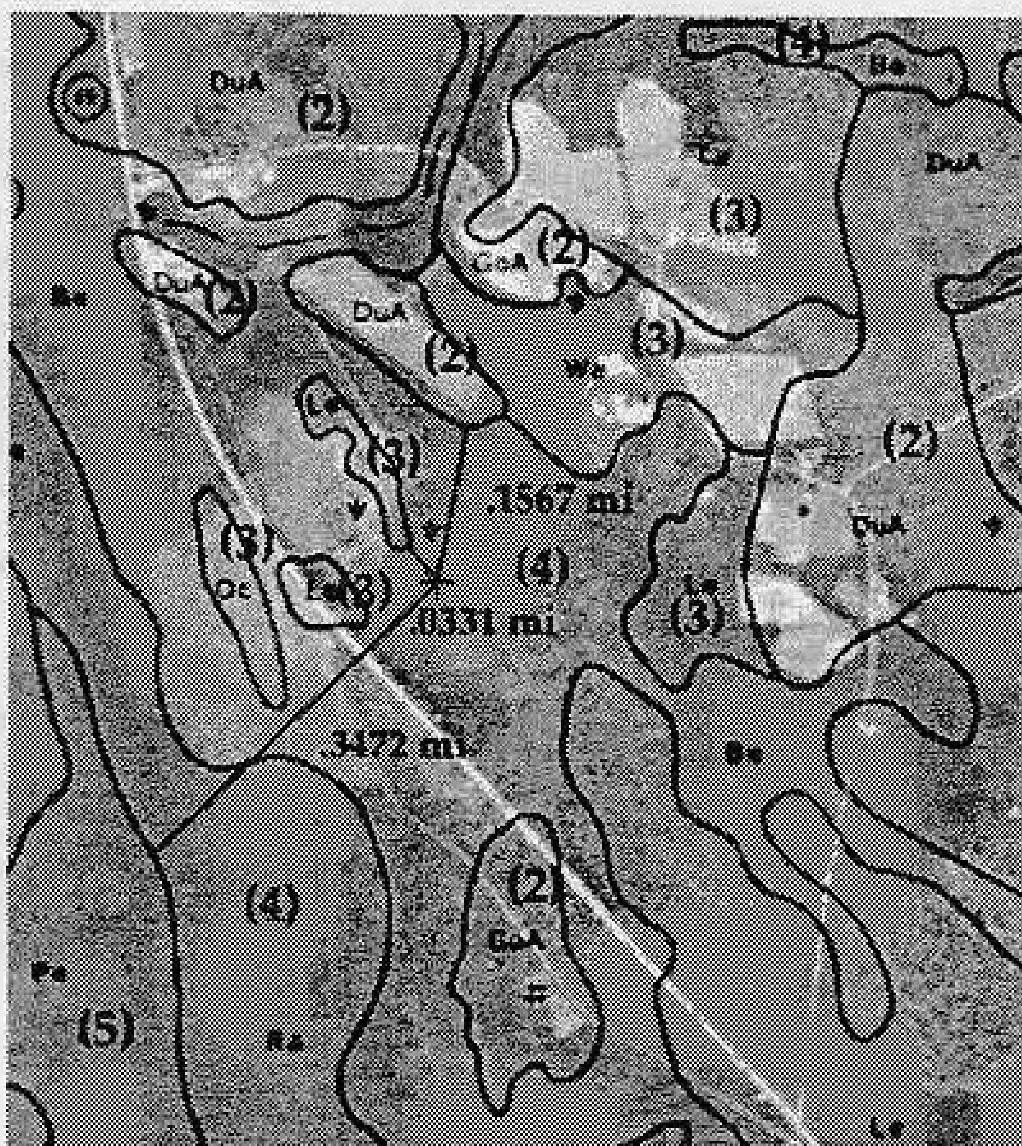
An example of the method is illustrated in Figure 12. Here, an enlarged section of Berkeley County Soil Sheet #48 is illustrated on which soil ranks and distance vectors have been overlaid. A cross-hair symbol represents a single point on a larger, control point grid of 0.1 mile nodes and three distance vectors are shown connecting the point to the nearest soil ranks. The control point is located on a large patch of Bethera loam (Be), which has a soil drainage rank of 4. This, then, is the value one would record for *DR0*. The nearest soil interface is with a drainage rank 3 soil type, Lenoir fine sandy loam (Le). Thus, the value of *CAT* for this control point would be 2.3 and the distance of .0331 miles would be recorded for both distance to nearest interface (*NEAR*) and *DR3*. The nearest rank 2 patch is 0.1567 miles distant from the control point and this value would be entered under *DR2*. The nearest rank 5 soil type patch, in turn, is located 0.3472 miles from the control point and this value would be entered under *DR5*. The nearest rank 1 patch is outside of the map window and therefore is not illustrated. Distances at the scale of 1 to 20,000 can be read at increments of .0033 miles (ca. 17.5 ft or 5.3 m) within Claris Draw.

Survey areas and site locations were scanned from 7.5 minute USGS maps and then exported into CLaris Draw files. Project boundaries, landmarks, and sites were then traced from these PICT files and exported into the SCS soil map files where they were overlaid on the soil maps using road locations as the principal matching justification. This required rescaling from the USGS scale of 1 to 24,000 to the SCS scale, a procedure that is done automatically from a command in Claris Draw. Once the project areas were imported and justified, control point grids were established and variable measurement commenced.

SCS Soil Type

As there is some variation in soil characteristics, the actual SCS soil type, referred to as the variable *SOIL* in this study, was also recorded for each data point. It was evident, for instance, that there were gradations within the soil hydrologic groups, as certain types of the same group were frequently found at higher elevations than other types. This was particularly evident in drainage rank 3 and 4 soil types. Recording this variable provided us with the opportunity to monitor this variation at a fine scale.

Figure 12. Method of distance measurement
for soil interfaces



Soil Interface Group

The variable *CAT*, or Soil Interface Category, is a nominal variable and as such does not contain within its structure an ordination that would allow us to rank individual values according to some function of soil drainage. Since this was a requirement of multiple regression analysis, we reordered the interface type data into three groupings that we thought might have meaning for predicting site location. These three states of the variable *INT*, or Soil Interface Group, consisted of dry, wet, and ecotonal combinations. Dry combinations included interfaces between ranks 1, 2, and 3 soil patches, while wet combinations included interfaces between soil patches of ranks 3, 4, 5, and 6. Ecotonal combinations were those interfaces composed of a dry rank (either a 1 or a 2) and a wet rank (a 4, 5, or 6) soil patch. Ecotonal combinations were considered to have the highest positive association with site location, while wet combinations were thought to have the lowest positive association. Dry combinations, therefore, were considered to occupy an intermediate position in this relationship. On this basis, ecotonal combinations were assigned an ordinal value of 1, dry combinations were assigned a value of 2, and wet combinations were given a value of 3.

Soil Drainage Rank Diversity

The diversity of nearby soil drainage ranks is an indication of the relative topographic variation and microenvironmental complexity of any particular location in coastal plain settings. Intuitively, it would seem that archaeological sites tend to be situated in locations of greater elevational relief, to take logistical advantage of ecotonal situations. We certainly know that this principal was adhered to in the early historic settlement of the lowcountry where locations interfacing between high ground and deep water were favored so that settlers could simultaneously take advantage of boat transportation and flood protection (South and Hartley 1980).

The method we chose to measure diversity was relatively simple: namely count the number of <u>different</u> soil drainage ranks within a specified radius of a site or control point. It is important to appreciate that not all soil type interfaces were counted, only the number of drainage ranks present. No matter how many soil types or patches of a particular drainage rank were present within a given radius, only the presence or absence of the drainage rank had relevance for the calculation of diversity. Thus, a given radius containing soil patches with drainage ranks of 1, 2, and 5, would have an associated diversity value of 3.

What we did not know at the outset was which radius would yield an optimal range of variation. Consequently a number of catchment radii were used to generate diversity measures. We selected radii of 0.05, 0.10, 0.20, and 0.30 miles, yielding the variables *H.05*, *H.10*, *H.20*. and *H.30*. The smallest of these, *H.05* (radius of 264 ft), measured the immediate soil diversity at a specific location, while the others measured the diversity at increasingly larger catchments. *H.10* recorded the diversity at a radius of 528 ft, *H.20* measured diversity at a radius of 1,056 ft, and *H.30* monitored diversity at a radius of 1,584 ft. An additional derived variable was generated to provide an estimate of the generalized soil diversity for each location. This was mean soil diversity, *Hx*, which was calculated by averaging the other four diversity measures.

Although these variables could have been measured manually in the CAD program using the stipulated catchment radii, this step was not necessary because the distances to the nearest soil drainage ranks from each site or control point had already been measured by variables *DR1*, *DR2*, *DR3*, *DR4*, *DR5*, and *DR6*. Their generation, then, required only the designing of several IF-THEN statements within our spread sheet data bases, we used EXCEL for this purpose, to calculate these variables. A somewhat more labor intensive method for accomplishing this that would not have required programming, would have been to sort the drainage rank distance variables one at a time.

Stream Rank Distances

Nearness to streams has consistently provided utility as a predictor variable in generalized site locational schemes. Although it was not found to have great predictive value in the AMOCO study (Scurry 1989), we wanted to explore this relationship further by seeing if particular ranks of streams might factor into site locational equations. The Strahler (1977) method of stream rank ordering was applied to the drainage network of the project area. The ranking data were derived from 7.5 minute USGS quadrangles. Individual streams were assigned ranks between 1, the smallest, and 6, the largest. Distances were measured from control points or sites to the nearest stream of each rank, within a cut-off distance of 2 miles. The distance variables were identified as *ST1*, *ST2*, *ST3*, *ST4*, *St5*, and *ST6*. An additional derived variable, distance to nearest stream (*STd*), was also calculated once these other distances were recorded. This was done, again, by using IF-THEN statements within our spreadsheet application.

Distance measurements were made on computerized SCS soil maps using the same method applied to the soil interface distances. In general, the soil maps show drainage systems in more detail than USGS maps and this proved to be somewhat of a problem. Since we were interested in limiting our measurements to locations supporting standing or running water, we endeavored to use the USGS maps as the standard for measurement. This was done by estimating the terminus of drainages on the SCS soil maps, as depicted on the USGS maps, and using these estimates as the basis for measurement.

Distance to Nearest Major Road

Major roads were defined, for the purposes of this study, as either U.S. highways or state highways where there is evidence that they served as major transportation routes historically. These measurements were also made on the computerized SCS maps.

Archaeological Site Spatial Variables

Two variables were generated for the purposes of serving as dependent (predicted) variables for the multiple regression analyses. These were: (1) nearest distance to an archaeological site (*SITEd*) and (2) site frequency within a radius of 0.20 miles (*SITE.2*). Both variables were measured on the computerized SCS maps. *SITEd* was recorded using vector distances, as has been described above for the other distance measures. Archaeological sites and control points resting on sites were assigned a distance value of 0. *SITE.2* was measured by sliding a circle with cross-hairs of radius 0.20 miles along the control point grid to each node and counting the number of sites occurring within the circle. This procedure was repeated over each archaeological site as well.

Coverage Radius

A final variable recorded for each control point is what we refer to as the coverage radius (*CR*). This is not an analysis variable, but rather a control variable intended to provide a scale of reliability for the site spatial measurements, since we can only be reasonably certain of site densities and site locations within an area that has been subjected to modern site discovery methodology. On the edges of the surveyed areas the spatial data we have generated on archaeological sites becomes increasingly unreliable because we do not know where sites exist in the unsurveyed areas immediately contiguous to the project areas. *CR* indicates the maximum area of certainty associated with each control point. It was measured simply by extending a circle out from each control point until either the limits of the surveyed area were reached or until a soil patch of drainage rank 3 or larger was encountered. Sites were rarely found in drainage rank 4 and 5 patches because these represent semi-saturated soil types situated in creek bottoms, swamps, and bays. Thus it was felt that the low likelihood of finding sites in these areas could be relied upon as a factor in determining the coverage radius. This variable provided us with the option of gradually reducing the sample of cases to those of higher certainty in the process of constructing the predictive models.

VI. Descriptive Analysis of the Samples

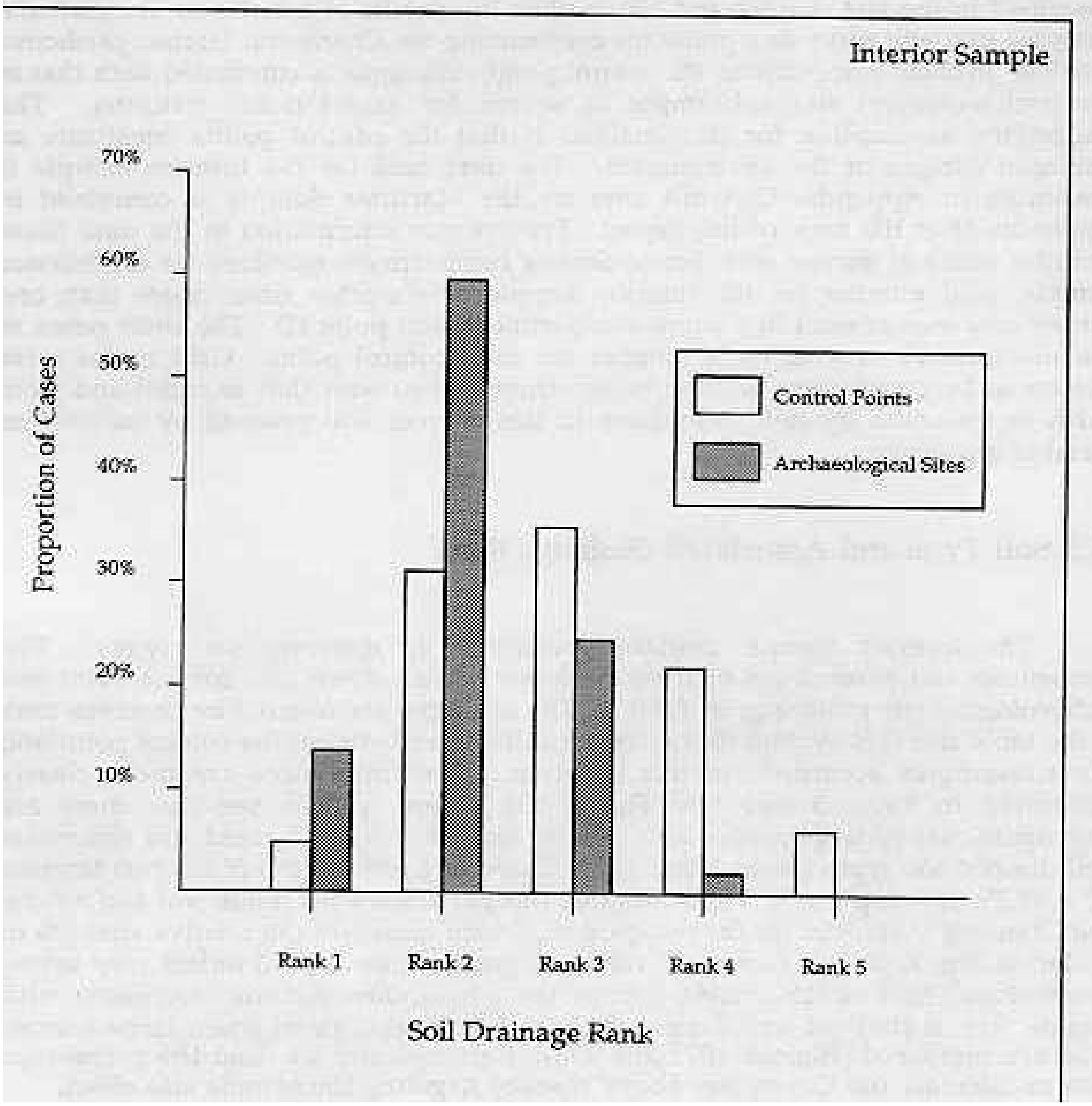
This chapter will present descriptive statistics for the spatial variables described in the last chapter and also outline the results of a series of associational analyses that will serve as a guide for constructing the Charleston Harbor predictive models. In these comparisons the control point subsample is contrasted with that of the archaeological site subsample to search for associational patterns. The underlying assumption for this analysis is that the control points constitute an unbiased sample of the environment. The data base for the Interior Sample is presented in Appendix C, while that for the Maritime Sample is contained in Appendix D at the back of this report. Provenience information in the data bases includes name of survey area, Forest Service compartment numbers for the Interior Sample, grid number for the Interior Sample where often times more than one survey area was present in a single compartment, and point ID. The latter refers to the site number or grid node number for each control point. Grid nodes were numbered by consecutive whole integers from east to west (left to right) and from north to the south by row. Discussion in this chapter will proceed by variable or variable grouping.

SCS Soil Type and Associated Drainage Rank

The Interior Sample contains twenty-seven different soil types. The frequencies and percentages of these types are broken down into control point and archaeological site groupings in Table 4. The soil types are ordered by drainage rank in the table and it is evident that there are differences between the control point and site subsamples according to this criterion. The differences are more clearly illustrated in Table 5 (see also Figure 13). Here we can see that there are disproportionately large proportions of sites located on well drained and somewhat well drained soil types (ranks 1 and 2). A Chi-square comparison of the two samples ($X^2 = 38.25$, df = 4, p = .0001) indicates that this pattern is both significant and strong. The Cramer's V statistic for the comparison, which measures the relative strength of a relationship, is .437. Cramer's V values of greater than .2 or .3 reflect very strong associations (Blalock 1972:298). Since the Chi-square statistic increases with sample size, statistical significance tends to be overestimated when large sample sizes are compared (Blalock 1972:292-293). Consequently we used the percentage data to calculate the Chi-square above, thereby negating the sample size effect.

Similar patterns can be observed in the Maritime Sample. Table 6 compares the frequency and percentage data for the control points and archaeological sites in this sample. Although far fewer soil types are present, only thirteen, the apparent relationship between archaeological sites and well drained and somewhat well drained soils is again documented. Table 7 shows the grouped data by drainage rank. Here we see that archaeological sites are also associated with somewhat poorly drained soils (rank 3). One factor that obscures the patterns is the dominant position occupied by salt marsh soils (rank 6) in the control point sample. This tends to artificially reduce the representation of drier soil types and exaggerates the differences between the two subsamples. In an effort to examine this relationship in more depth we removed the rank 5 and 6 soils from the comparison and recomputed the proportional representations of the other rankings (Table 8). This did indeed lessen the contrasts, but there were clear differences between the distributions of ranks 2 and 4 soil types; the former being more frequently associated with archaeological sites and

Figure 13. Histogram of Soil Drainage Rank, Interior Sample



the latter occurring more frequently with the control point subsample (Figure 14). A Chi-square comparison of the adjusted drainage rank percentages confirmed this inference (X^2 = 11.67, df = 3, p = .0086, Cramer=s V = .242). The association is not as strong as the one for the Interior Sample, but it would nevertheless appear to point toward significant trends in the data base.

Important differences between the samples also obtain. The most obvious of these is the presence of a large proportion of salt marsh in the Maritime sample. A difference of much more importance, however, is the general tendency for the Maritime Sample sites to be situated on more poorly drained soil patches. A Chi-square comparison of ranks 1 through 4 for the two site subsamples, in fact, indicates that these differences are significant and strong (X^2 = 24.28, df = 3, p = .0001, Cramer=s V = .354). These comparisons heavily influenced our decision to segregate the two environmental zones and to develop separate predictive models for each.

Soil Interface Distances

Distances to soil drainage rank interfaces were examined by unpaired t-test comparisons. Table 9 presents the data for the Interior Sample. Indicated in the table are four comparisons between the site and control point subsamples that have statistical significance. These are distance to nearest soil drainage interface (*NEAR*), and nearest distances to soil patches of drainage ranks 1, 2, and 3, or *DR1*, *DR2*, and *DR3*. The mean distance to the nearest soil interface for the control point subsample is about 40 percent larger than the mean for the site subsample. Sites are situated at a mean distance of approximately 182 ft or 71.6 m from the nearest soil interface, while control points are positioned at a mean distance of about 256 ft or 100.8 m from the nearest soil interface. Archaeological sites also appear to be closer, on the average, to soil patches of drainage ranks 1 and 2, while they are located farther from soil patches of drainage rank 3. There are no clear-cut differences in the remaining drainage ranks. Most of the significant differences would seem to have predictive value. The exception to this is *DR1*, where mean distances for both subsamples are extremely large.

Table 4. Soil type representation for the Interior Sample.

		Control Points		Archaeological Sites	
Rank	Soil Type	Count	Percent	Count	Percent
1	CaB	3	0.28	6	3.06
1	CoA	3	0.28	2	1.02
1	CoB	32	3.03	13	6.63
1	NoA	10	0.94	6	3.06
1	NoB	3	0.28		
2	BoA	20	1.89	9	4.59
2	Ct	156	14.8	51	26.00
2	CvA	18	1.70	7	3.57
2	CvB	17	1.61	6	3.06
2	DuA	27	2.55	10	5.10
2	DuB	14	1.32	10	5.10
2	GoA	77	7.28	24	12.20
3	Le	66	6.24	9	4.59
3	Ly	85	8.04	10	5.10
3	Oc	6	0.57	4	2.04
3	TA	1	0.10		
3	Wa	134	12.70	17	8.67
3	Wt	85	8.04	8	4.08
4	Be	124	11.70	1	0.51
4	Cu	1	0.10		
4	Lo	7	0.66		
4	Mg	37	3.50	1	0.51
4	Ra	65	6.15	2	1.02
5	Ba	32	3.03		
5	Pa	1	0.10		
5	Pe	11	1.04		
5	Pk	22	2.08		
Totals		1,057		196	

Table 5. Comparison of soil drainage rank representations, Interior Sample.

Drainage Rank	Control Points		Archaeological Sites	
	Count	Percent	Count	Percent
1	51	4.83	27	13.78
2	329	31.15	117	59.62
3	377	35.68	48	24.48
4	234	22.11	4	2.04
5	66	6.25	0	0.00

Figure 14. Histogram of Soil Drainage Rank, Maritime Sample

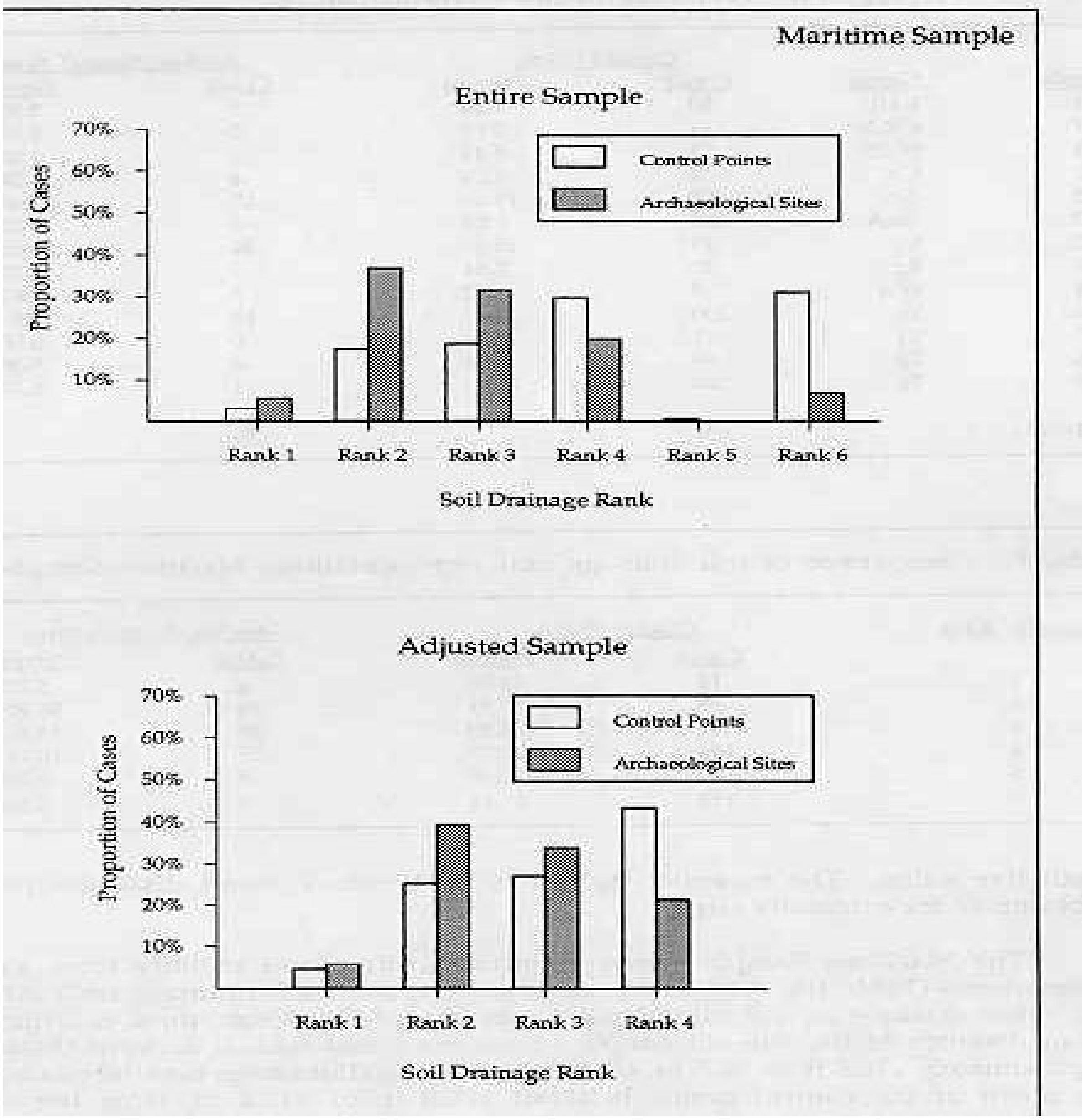


Table 6. Soil type representation for the Maritime Sample.

Control Points				Archaeological Sites	
Rank	Group	Count	Percent	Count	Percent
1 LaB	10	2.04	3	3.95	
1 ORA	3	0.61	0	0.00	
1 WgB	2	0.41	1	1.32	
2 Ch	5	1.02	4	5.26	
2 Cm	55	11.20	17	22.40	
2 HoA	25	5.09	7	9.21	
3 Sf	91	18.50	24	31.60	
4 Rg	37	7.54	1	1.32	
4 Wa	9	1.83	2	2.63	
4 Yo	100	20.40	12	15.80	
5 St	1	0.20	0	0.00	
6 Cg	49	9.98	4	5.26	
6 Ts	104	21.20	1	1.32	
Totals		491		76	

Table 7. Comparison of soil drainage rank representations, Maritime Sample.

Drainage Rank		Control Points		Archaeological Sites
Count		Percent	Count	Percent
1	15	3.06	4	5.27
2	85	17.31	28	36.87
3	91	18.50	24	31.60
4	146	29.77	15	19.75
5	1	0.20	0	0.00
6	153	31.18	5	6.58

The Maritime Sample shows significant differences in only three variable comparisons (Table 10). The first is distance to nearest soil drainage rank interface. The mean distance for the control point subsample is over two times as large as the mean distance of the site subsample. Sites are positioned at a mean distance of approximately 118.8 ft, or 46.8 m, from the nearest soil drainage rank interface, while the mean of the control points is about 279.8 ft, or 110.2 m, from the nearest interface. Another significant difference is represented by the mean distance to the nearest drainage rank 2 soil patch (*DR2*). Sites are on the average closer to drainage rank 2 soil patches than control points, although both subsamples have relatively small means on this variable. The final significant difference is the mean distance from the nearest salt marsh soil patch. The mean distance for the site subsample is 385.4 ft, or 151.8 m, while the mean for the control point subsample is 598.8 ft, or 235.7 m. The remainder of the comparisons do not show great differences, although sites may also be closer to drainage rank 3 soil patches as the mean difference between the two subsamples is nearly one-tenth of a mile.

Table 8. Adjusted comparison of soil drainage rank representations, Maritime Sample.

Drainage Rank	Control Points		Archaeological Sites	
	Count	Percent	Count	Percent
1	15	4.45	4	5.63
2	85	25.22	28	39.44
3	91	27.00	24	33.80
4	146	43.32	15	21.13

Table 9. T-Test comparisons for soil interface distances, Interior Sample.

Sites (n=196)		Control Pts (n=1,057)				
Variable	Mean	SD	Mean	SD	t-Score*	Prob.
NEAR	0.03450.0394	0.0484	0.0559	3.319	.0004	
DR1	0.71650.7587	0.8733	0.7960	2.550	.0054	
DR2	0.07730.1969	0.1998	0.3307	5.026	.0001	
DR3	0.18910.2941	0.1326	0.2422	2.895	.0019	
DR4	0.13200.1439	0.1260	0.1632	0.483	.3146	
DR5	0.25340.3398	0.2939	0.3751	1.408	.0797	

* Significant differences at the .05 probability level are underlined

Soil Interface Category and Type

Tables 11 and 12 display summary frequency data on the distribution of *CAT*, soil interface category, and *INT*, soil interface type, for sites and control points within the Interior Sample. Identifiable in these tables is a clear and strong association of ecotonal interfaces and archaeological site locations (Figure 15). The Chi-square statistic (X^2 = 17.53, df = 2) for the comparison of interface type between the site and control point subsamples in Table 12 is significant at the .0002 probability level and the computed Cramer=s V of .296 indicates a relatively strong relationship. The control point subsample is characterized by a dominance of wetter interfaces.

Table 10. T-Test comparisons for soil interface distances, Maritime Sample.

Variable	Sites (n=76) Mean	SD	Control Pts (n=491) Mean	SD	t-Score*	Prob.
NEAR	0.0225	0.0333	0.0530	0.0615	<u>4.231</u>	.0001
DR1	0.4270	0.2861	0.4226	0.2504	0.140	.4444
DR2	0.0889	0.1127	0.1196	0.1146	<u>2.182</u>	.0148
DR3	0.2996	0.4647	0.3840	0.4369	1.554	.0604
DR4	0.0577	0.0705	0.0682	0.0894	0.976	.1648
DR5	0.9128	0.6419	0.8593	0.6265	0.690	.2454
DR6	0.0730	0.1257	0.1134	0.1494	<u>2.241</u>	.0127

* Significant differences at the .05 probability level are underlined

Table 11. Frequency summaries of soil interface category (CAT), Interior Sample.

CAT	INT	Archaeological Sites Count	Percent	Control Points Count	Percent
1.4	1	12	6.1	29	2.7
1.5	1	5	2.6	18	1.7
2.4	1	37	18.9	125	11.8
2.5	1	45	23.0	138	13.1
1.2	2	21	10.7	52	4.9
1.3	2	3	1.5	10	0.9
2.3	2	35	17.9	192	18.2
3.4	3	21	10.7	316	29.9
3.5	3	15	7.7	88	8.3
4.5	3	2	1.0	89	8.4
Total		196		1057	

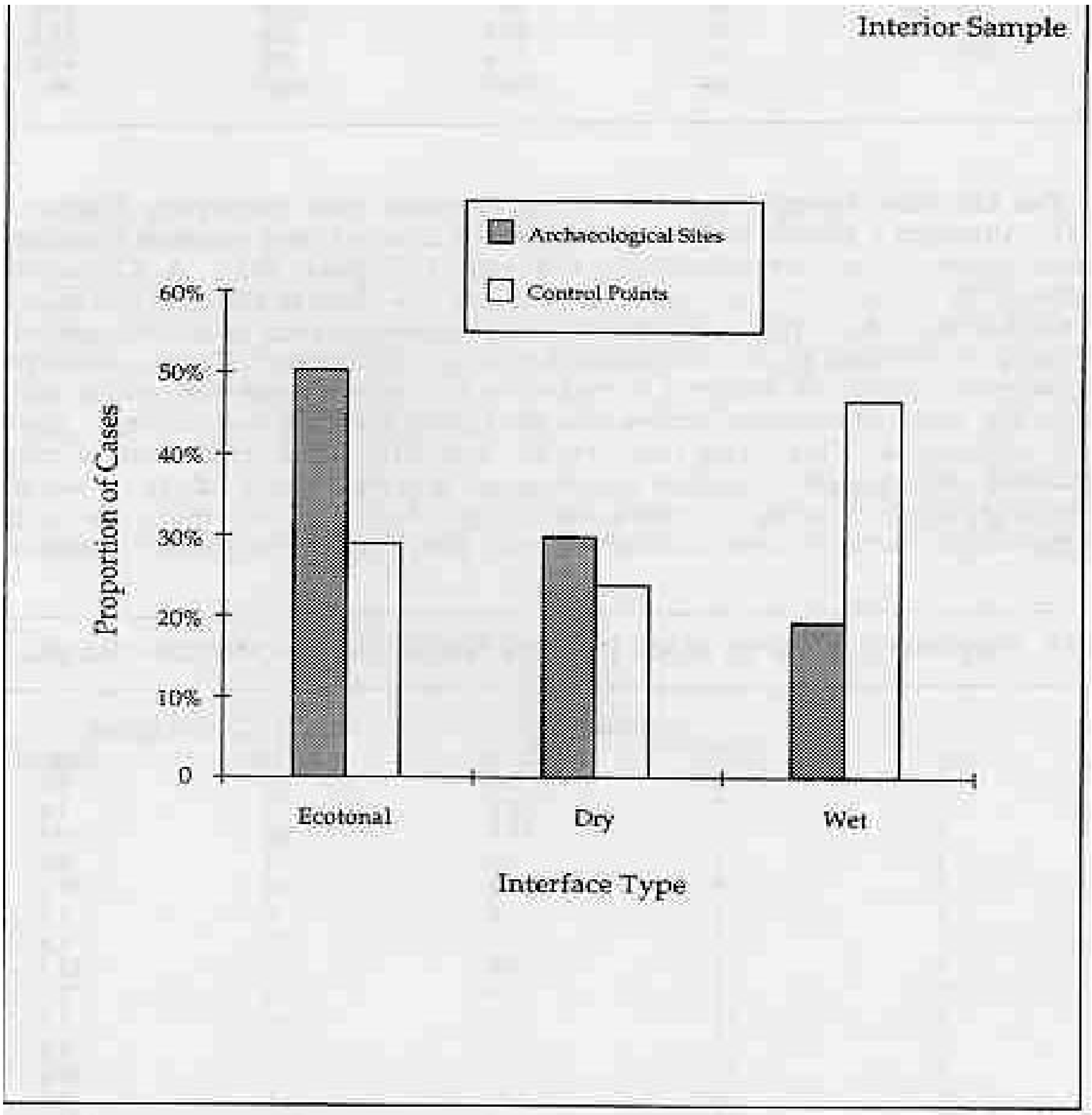


Figure 15. Histogram of Soil Interface Type (INT), Interior Sample

Table 12. Frequency summaries of soil interface type (INT), Interior Sample.

		Sites		Control Points	
INT	Description	Count	Percent	Count	Percent
1	Ecotonal	99	50.5	310	29.3
2	Dry	59	30.1	254	24.0
3	Wet	38	19.4	493	46.6
Total		196	100.0	1057	99.9

The Maritime Sample does not exhibit the same clear patterning (Tables 13 and 14). Although a greater proportion of sites are situated near ecotonal interfaces, the association is neither significant nor strong (Figure 16). A Chi-square comparison (X^2 = 1.806, df = 2, p = .4054, Cramer's V = .095) of the data in Table 14 indicates that the control point and site subsamples may, in fact, be undifferentiated with regard to interface type. One detail that might influence this result, however, is the predominance of the wetter, 4.6 category in the control point subsample, while the drier, 3.6 interface category comprises a good portion of the wet interface type in the site subsample. This latter category, on a relative scale, represents a more ecotonal-like setting than the former and suggests that sites in the Maritime sample do have a tendency to occupy ecotonal interfaces. Again, we see that sites in the Maritime Sample occupy wetter locations overall than sites in the Interior Sample.

Table 13. Frequency summaries of soil interface category (CAT), Maritime Sample.

		Sites		Control Points	
CAT	INT	Count	Percent	Count	Percent
1.4	1	1	1.3	12	2.4
1.6	1	3	4.0	7	1.4
2.4	1	13	17.1	84	17.1
2.5	1	0	0.0	3	0.6
2.6	1	14	18.4	55	11.2
1.2	2	1	1.3	9	1.8
2.3	2	8	10.5	42	8.6
3.4	3	5	6.6	66	13.4
3.5	3	1	1.3	8	1.6
3.6	3	15	19.7	43	8.8
4.5	3	0	0.0	3	0.6
4.6	3	15	19.7	158	32.2
5.6	3	0	0.0	1	0.2
Total		76	100.0	491	100.0

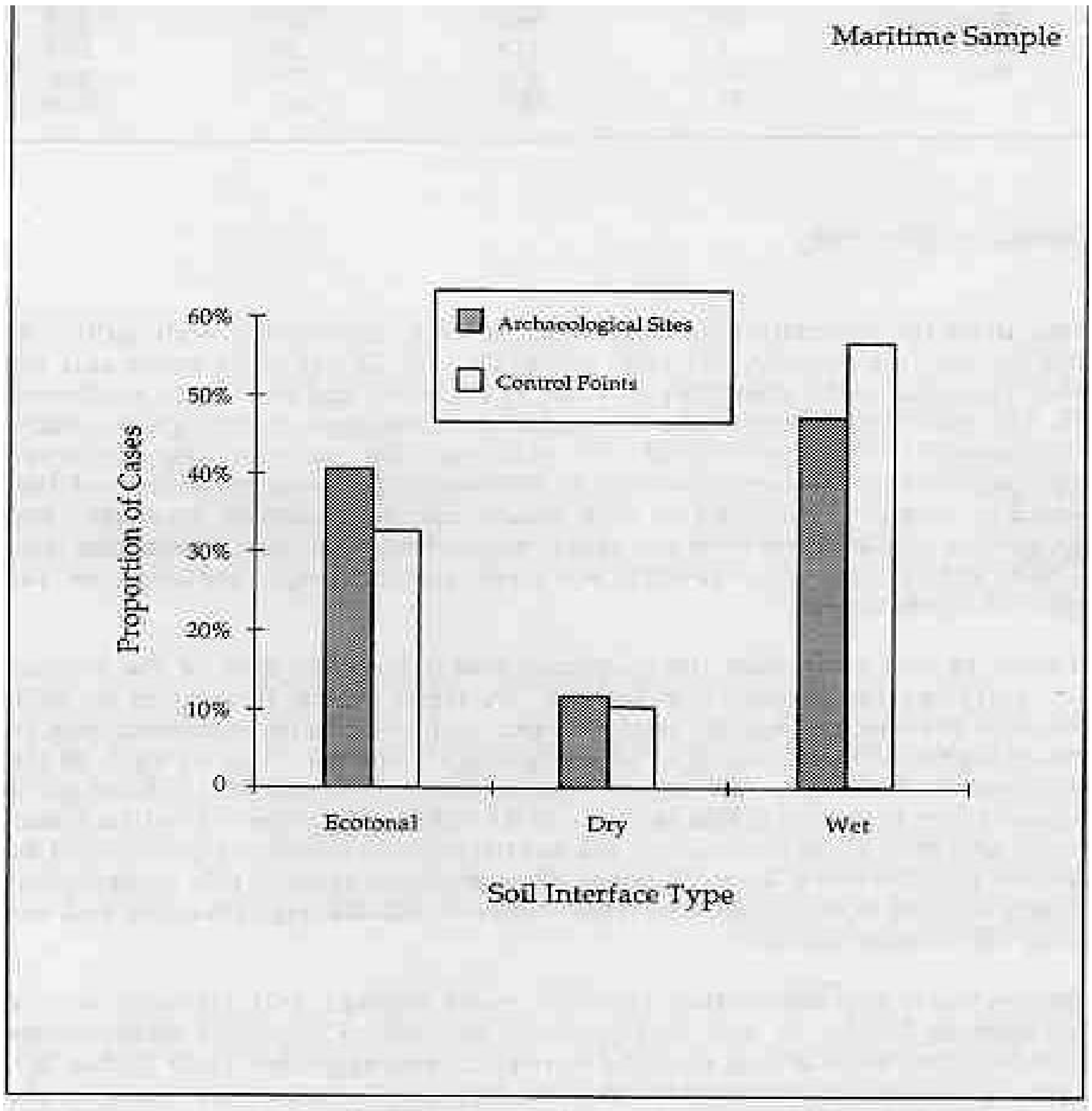


Figure 16. Histogram of Soil Interface Type (INT), Maritime Sample

Table 14. Frequency summaries of Soil Interface Type (INT), Maritime Sample.

		Archaeological Sites		Control Points	
INT	Description	Count	Percent	Count	Percent
1	Ecotonal 31	40.8	161	32.8	
2	Dry	9	11.8	51	10.4
3	Wet	36	47.4	279	56.8
Total		76	100.0	491	100.0

Soil Drainage Diversity

Soil drainage diversity was calculated for four concentric search radii. As discussed in the last chapter, the radii were .05, .10, .20, and .30 miles and the respective variables were identified as *H.05*, *H.10*, *H.20*, and *H.30*. An additional variable, *Hx*, was derived from the other four as a measure of average diversity. These measures were generated to examine the relationship between microtopography, ecotonal settings and site location; and it was hypothesized that sites would be situated on landforms with greater microtopographic diversity. Soil drainage patterns reflect this variation much more effectively than elevational data from USGS maps and consequently we used soil drainage rankings in the calculation of these variables.

Tables 15 and 16 present the frequency and percentage data of the various diversity variables for the Interior Sample. A trend which is evident in each breakdown is that archaeological sites do tend to have greater representation in locations of higher soil drainage diversity (Figures 17 and 18). The strength of the association varies, however. Chi-square comparisons of the site and control point subsamples (Table 17) indicate that only the H.30 and Hx variables exhibit statistical significance and even these associations are not particularly strong, as is indicated by the relatively low Cramer=s V calculations. We can conclude from this analysis that there is only a slight to moderate association between soil drainage diversity and site location in the Interior Sample.

By contrast, the association is much more evident and stronger in the Maritime Sample (Tables 18 and 19, Figures 19 and 20). Chi-square comparisons indicate significant associations for all diversity measures except H.30 (Table 20). The Cramer=s V calculations indicate that the strongest associations occur in the smaller radii (ie. .05 and .10 miles). Mean diversity (Hx) also produces a significant and strong association. Clearly, what these results indicate is that soil patches are larger in the interior, which results in less diversity in the smaller radii. In turn, soil patches are smaller along the coast, resulting in greater diversity in the smaller radii. Again, we see significant differences in the structure of soil distributions in the two samples that justify their segregation for model building.

Table 15. Frequency and percentage summaries for H.05, H.10, H.20, and H.30, Interior Sample.

	Archaeological Sites		Control Points	
H.30	Frequency	Percent	Frequency	Percent
2.00	5	2.6	142	13.4
3.00	58	29.6	349	33.0
4.00	97	49.5	443	41.9
5.00	36	18.4	123	11.6
	196		1057	
H.20	Frequency	Percent	Frequency	Percent
1.00	2	1.0	8	0.8
2.00	27	13.8	291	27.5
3.00	90	45.9	395	37.4
4.00	59	30.1	316	29.9
5.00	18	9.2	47	4.5
Total	196		1057	
H.10	Frequency	Percent	Frequency	Percent
1.00	14	7.1	138	13.1
2.00	73	37.2	497	47.0
3.00	87	44.4	326	30.8
4.00	22	11.2	91	8.6
5.00			5	0.5
Total	196		1057	
H.05	Frequency	Percent	Frequency	Percent
1.00	46	23.5	360	34.1
2.00	101	51.5	521	49.3
3.00	45	23.0	161	15.2
4.00	4	2.0	15	1.4
Total	196		1057	

Table 16. Frequency and percentage summaries for mean soil drainage rank diversity (Hx), Interior Sample.

	Archaeological Sites		Control Points	
H.x	Frequency	Percent	Frequency	Percent
1.25	0	0.0	2	0.2
1.50	0	0.0	28	2.7
1.75	3	1.5	72	6.8
2.00	13	6.6	143	13.5
2.25	19	9.7	128	12.1
2.50	30	15.3	128	12.1
2.75	30	15.3	136	12.9
3.00	26	13.3	129	12.2
3.25	22	11.2	96	9.1
3.50	26	13.3	103	9.7
3.75	17	8.7	50	4.7
4.00	4	2.0	28	2.7
4.25	3	1.5	8	0.8
4.50	3	1.5	4	0.4
4.75			2	0.2
Total	196		1057	

Table 17. Summary of Chi-square comparisons for soil drainage diversity, Interior Sample.*

Diversity		Chi-square	Probability**	Cramer=s V	df	Groups***
	H.30	9.648	<u>.0218</u>	.220	3	2,3,4,5
	H.20	7.047	.1334	.188	4	1,2,3,4,5
	H.10	5.600	.1328	.167	3	1,2,3,4-5
	H.05	3.697	.2961	.136	3	1,2,3,4
	Hx	7.652	<u>.0538</u>	.196	3	0-1.75,2-2.75, 3-3.75, 4-4.75

* Comparisons were based on percentage data rather than raw counts.

** Significant Associations at a .05 probability level are underlined.

*** Comparisons at times required grouping diversity ranges to satisfy assumptions concerning @0? cells.

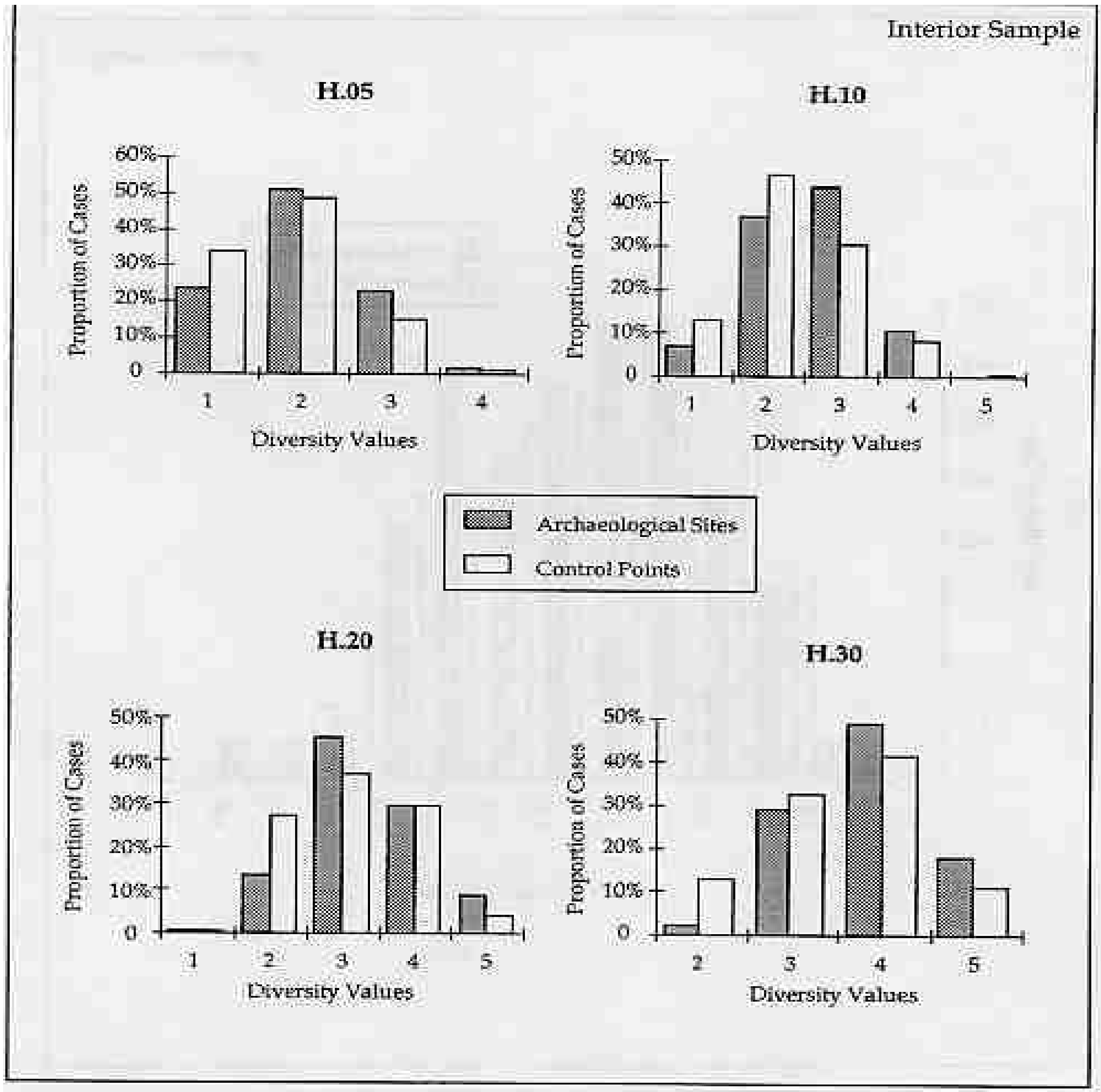


Figure 17. Histograms of diversity radii, Interior Sample

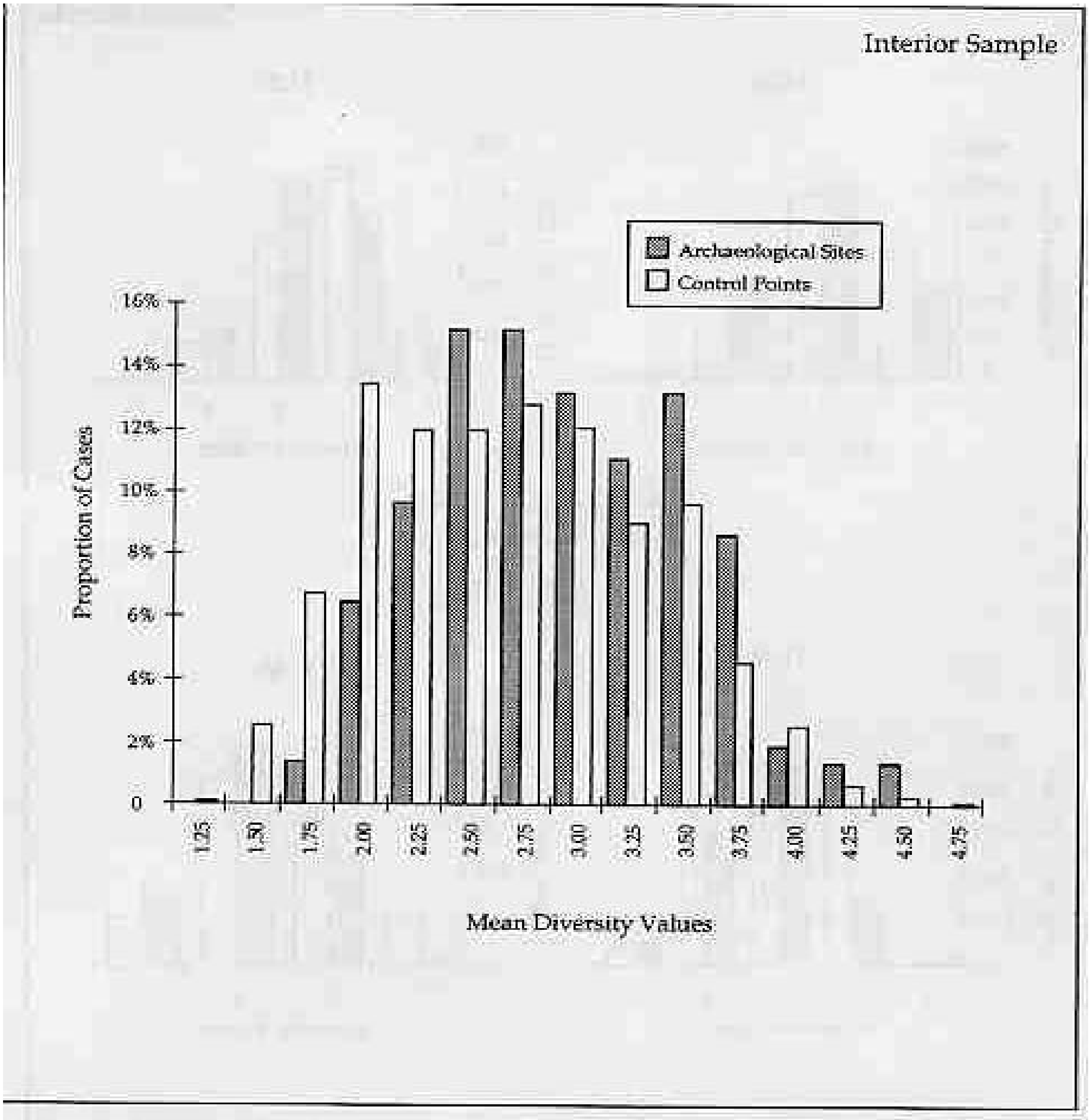


Figure 18. Histogram of mean soil diversity (Hx), Interior Sample

Table 18. Frequency and percentage summaries for H.05, H.10, H.20, and H.30, Maritime Sample.

	Archaeological Sites		Control Points	
H.30	**Frequency**	**Percent**	**Frequency**	**Percent**
1.00	0	0.0	5	1.0
2.00	4	5.3	37	7.5
3.00	12	15.8	130	26.5
4.00	37	48.7	168	34.2
5.00	23	30.3	146	29.7
6.00	0	0.0	5	1.0
Total	76		491	
H.20	**Frequency**	**Percent**	**Frequency**	**Percent**
1.00	0	0.0	16	3.3
2.00	9	11.8	77	15.7
3.00	16	21.1	174	35.4
4.00	41	53.9	176	35.8
5.00	10	13.2	48	9.8
Total	76		491	
H.10	**Frequency**	**Percent**	**Frequency**	**Percent**
1.00	1	1.3	67	13.6
2.00	21	27.6	196	39.9
3.00	35	46.1	173	35.2
4.00	17	22.4	52	10.6
5.00	2	2.6	3	0.6
Total	76		491	
H.05	**Frequency**	**Percent**	**Frequency**	**Percent**
1.00	11	14.5	163	33.2
2.00	37	48.7	234	47.7
3.00	24	31.6	90	18.3
4.00	4	5.3	4	0.8
Total	76		491	

Table 19. Frequency and percentage summaries for mean soil drainage rank diversity (Hx), Maritime Sample.

	Archaeological Sites	Control Points
H.x	FrequencyPercent	FrequencyPercent
1.00	00.0	51.0
1.25	00.0	71.4
1.50	00.0	142.9
1.75	00.0	142.9
2.00	56.6	346.9
2.25	45.3	5411.0
2.50	45.3	489.8
2.75	45.3	6212.6
3.00	911.8	5811.8
3.25	1722.4	5511.2
3.50	1317.1	6413.0
3.75	1013.2	449.0
4.00	79.2	173.5
4.25	22.6	112.2
4.50	00.0	40.8
4.75	11.3	00.0
Total	76100.0	491100.0

Table 20. Summary of Chi-square comparisons for soil drainage diversity, Maritime Sample.*

Diversity	Chi-square	Probability**	Cramer=s V	df	Groups***
H.30	5.987	.1122	.173	3	1-2,3,4,5-6
H.20	9.457	<u>.0238</u>	.217	3	1-2,3,4,5
H.10	19.117	<u>.0003</u>	.309	3	1,2,3,4-5
H.05	14.210	<u>.0026</u>	.266	3	1,2,3,4
Hx	18.94	<u>.0003</u>	.308	3	0-1.75,2-2.75, 3-3.75, 4-4.75

* Comparisons were based on percentage data rather than raw counts.

** Significant Associations at a .05 probability level are underlined.

*** Comparisons at times required grouping diversity ranges to satisfy assumptions concerning @0? cells.

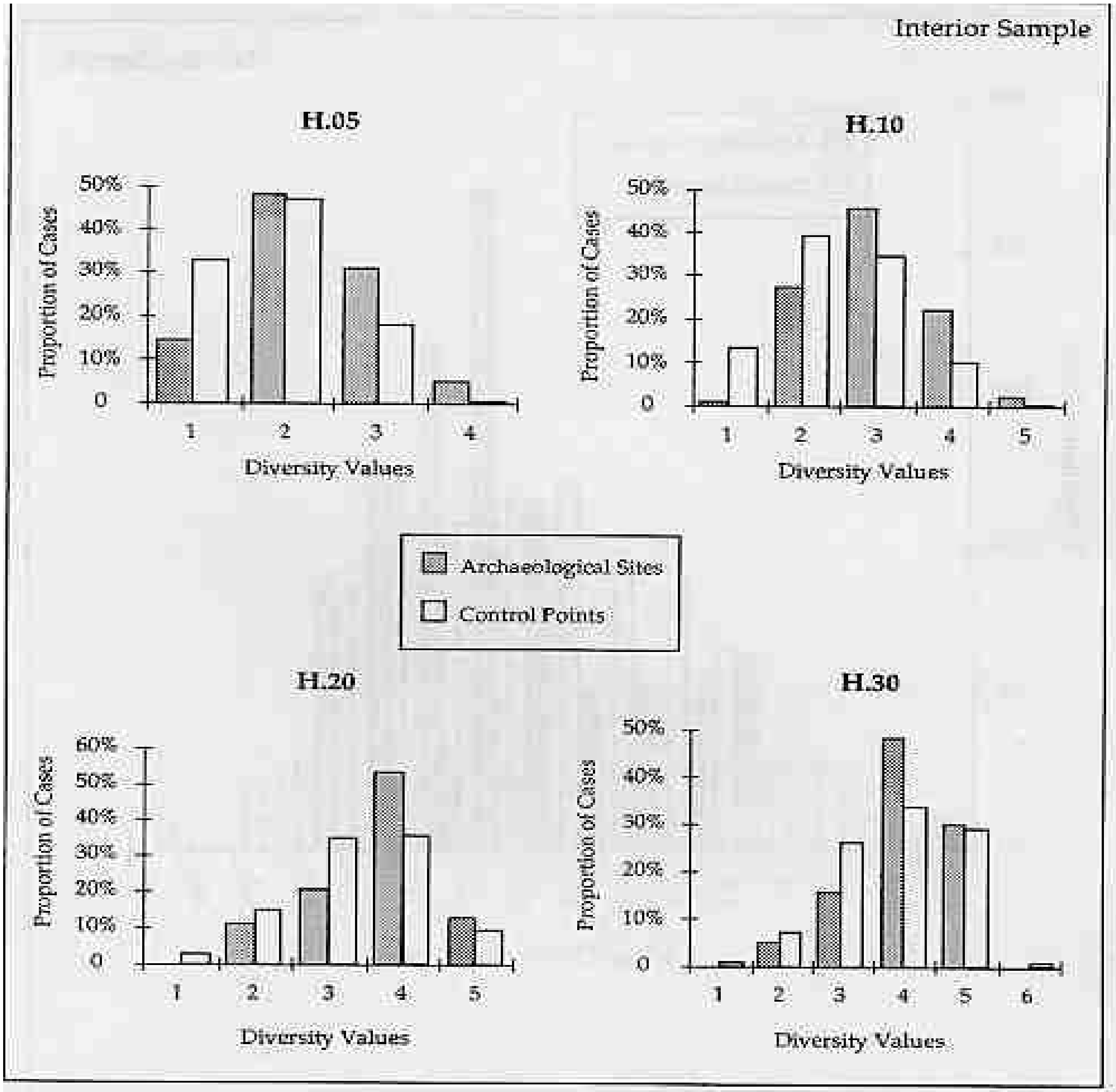


Figure 19. Histograms of diversity radii, Maritime Sample

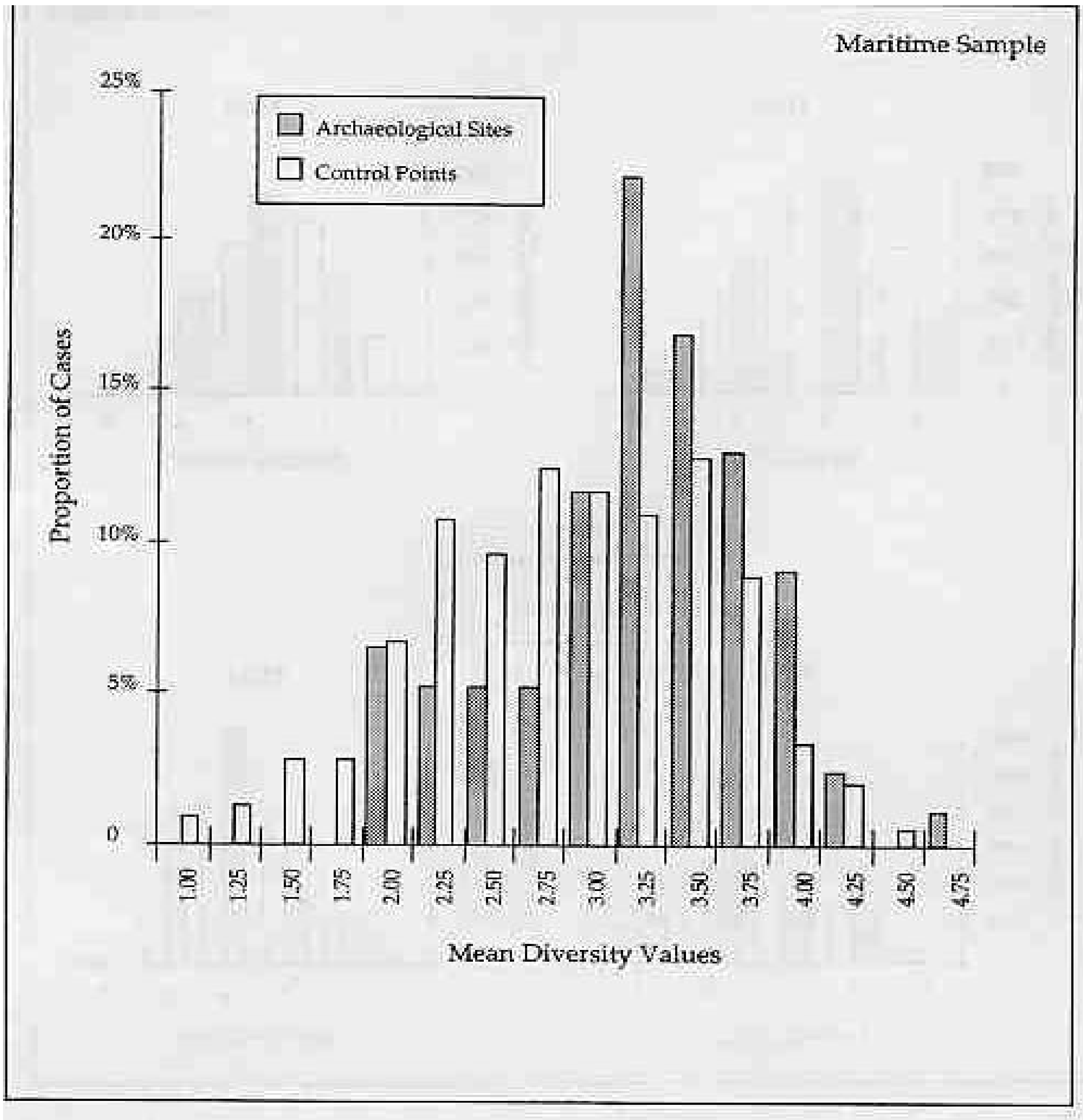


Figure 20. Histogram of mean soil diversity (Hx), Interior Sample

Distance To Streams

During the course of measuring and recording data it became necessary to scale back the distance to stream variables because of time considerations. Since streams within a 2 mile radius of the control grids were generally limited to the first three ranks, the larger ranks were collapsed into a single variable, *ST≥3*, for the Interior Sample. In addition, we recorded only distance to nearest stream, *STd*, for approximately one-quarter of the Interior Sample. The Maritime Sample was paired back from the beginning. Here, three stream distance variables were recorded: distance to nearest stream (*STd*), distance to nearest stream of rank 1 or 2, *ST1-2*, and distance to nearest stream of rank 3 or greater.

Table 21 presents the summary statistics on distance to stream data by subsample for the Interior and Maritime Samples. None of the means for the Interior Sample indicate that streams were necessarily close to sites or that there was much difference between the site and control point subsamples. The mean distance for rank 1 streams is 0.385 miles, or ca. 2,033 ft, while the mean distance to higher ranked streams is greater than 1 mile. The mean distance to nearest stream for the site subsample, *STd*, is also quite large, over 1,500 ft. The Maritime Sample exhibits much smaller distance relationships. The mean distances for the site subsample for variables *ST1-2*, *ST≥3*, and *STd* are respectively 1161, 2882, and 850 ft.

Table 21. Summary statistics for distance to stream variables, Interior and Maritime Samples.

			Archaeological Sites		Control Points	
Sample	Variable	N	Mean	SD	Mean	SD
Interior	ST1	874	.385	.359	.413	.388
Interior	ST2	872	1.012	.876	1.147	.816
Interior	ST≥3	809	1.728	1.251	1.945	1.118
Interior	STd	1245	.300	.298	.332	.308
Maritime	ST1-2	566	.220	.189	.326	.229
Maritime	ST≥3	565	.546	..492	.612	.472
Maritime	STd	564	.161	.163	.239	.184

A series of t-tests comparing the site and control point subsamples (Table 22) show some significant differences in the Interior Sample, but these do not seem to have much promise for the predictive model because the mean distances are large and individual cases deviate broadly around the means. A possible exception to this is the variable *STd*, which has a smaller variance which is comparable to the soil drainage variables. The t-value of the comparison for this variable is not significant at the .05 level of probability, but it is at the .10 level. In statistical terms there is a probability of less than 1 chance in 10 that the control point and site subsamples are the same. *STd*, then, was considered to potentially exert influence in predicting site location.

Table 22. T-Test comparisons of distance to stream variables for Sites and Control Points, Interior and Maritime Samples.

Sample	Variable	df	t-value	Probability*
Interior	ST1	873	.782	.2171
Interior	ST2	871	1.759	<u>.0395</u>
Interior	ST≥3	808	1.972	<u>.0245</u>
Interior	STd	1244	1.349	.0887
Maritime	ST1-2	565	3.839	<u>.0001</u>
Maritime	ST3-4	564	1.134	.1287
Maritime	STd	563	3.502	<u>.0002</u>

* Underlined Cases Indicate Statistical Significance at the .05 Probability Level.

The two significant comparisons in the Maritime Sample indicate that both *ST1-2* and *STd* have predictive power for site location. In each case the mean distance is comparatively small and the associated variance is small. The variables are dependent on one another and only one could be used in model formation in a single equation.

Distance to Roads

Our strategy of measuring distances to major roads and highways was tested out after the Interior Sample was completed and before the Maritime Sample was drawn up. We found that although there was a statistically significant difference between the site and control point subsamples in the Interior Sample, the means and variances of each were large. The central tendency measures for the site and control point subsamples were respectively 0.98797 _ 0.79418 miles and 1.2120 _ 0.9021 miles. This suggested to us that there was too much variation in the variable to provide a reliable predictor. It is likely that a much more detailed study of historic roadways would be needed before some expression of this variable could be generated that would be useful for modelling. Such a study might also benefit from ranking the roadways. This study was unable to devote the time to develop such a system. Concluding that the variable would be of little use in the Maritime Sample as well, we eliminated it from further consideration.

Site Spatial Variables

The two site spatial variables selected for this study are *SITEd*, distance to nearest site, and *SITE.2*, the number of sites within a 0.2 miles radius of a control point or site. There is very little that can be said at this juncture about *SITEd* other than a comparison of the central tendency data for the samples. The means and standard deviations for the control point subsamples of the Interior and Maritime Samples respectively are 0.2692 _ 0.2432 and 0.1550 _ 0.1094 miles. From this we can see that sites are much denser in the Maritime project areas. More about this disparity in site densities will be discussed in the final chapter.

Tables 23 and 24 present frequency and percentage data on the distribution of *SITE.2* by subsample for the Interior and Maritime Samples. In both samples greater site densities are present in the site subsamples (Figures 21 and 22). Chi-square comparisons of the subsamples indicate both significant and strong associations .

Collapsing the 0 and 1 values and the 4 and 5 values into single cells in the Interior Sample, a Chi-square of 35.1 is obtained (df = 3, p = .0001). The Cramer=s V for this comparison is .419. Collapsing the 0 and 1 values and the 7, 8, and 9 values into single cells in the Maritime Sample, an equally large Chi-square of 41.3 is calculated (df = 6, p = .0001). The Cramer=s V of .454 also indicates a strong association. What these patterns suggest is that site distributions in both samples are clustered and that this variable should provide an excellent basis for building a predictive model.

Table 23. Frequency and percentage breakdowns for *SITE.2*, Interior Sample.

SITE.2	Control Points Frequency	Control Points Percent	Archaeological Sites Frequency	Archaeological Sites Percent
0	487	46.1	0	0.0
1	323	30.6	70	35.7
2	178	16.8	79	40.3
3	49	4.6	25	12.8
4	15	1.4	21	10.7
5	5	0.5	1	0.5
Total	1057		196	

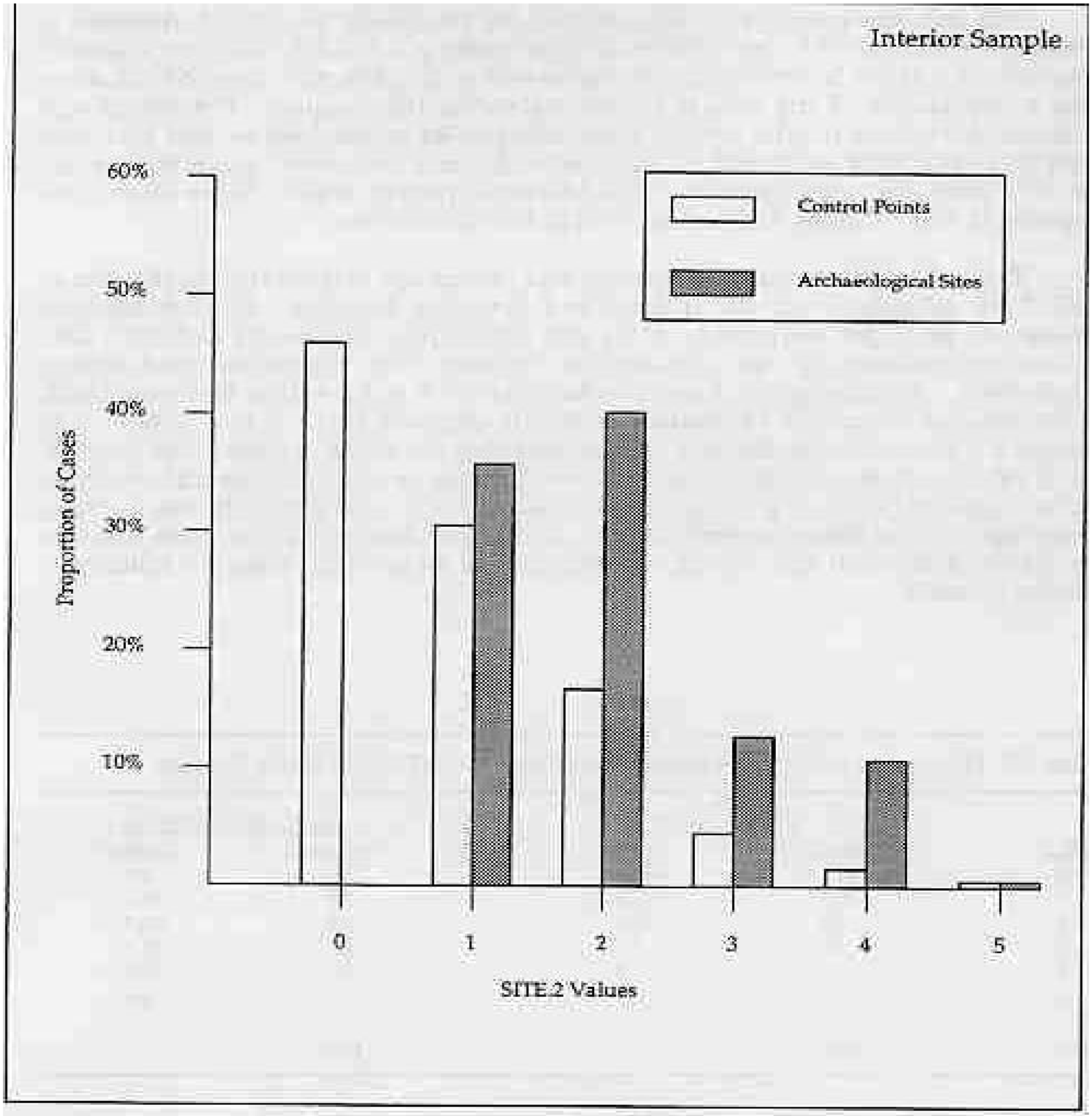


Figure 21. Distribution of variable SITE.2, Interior Sample

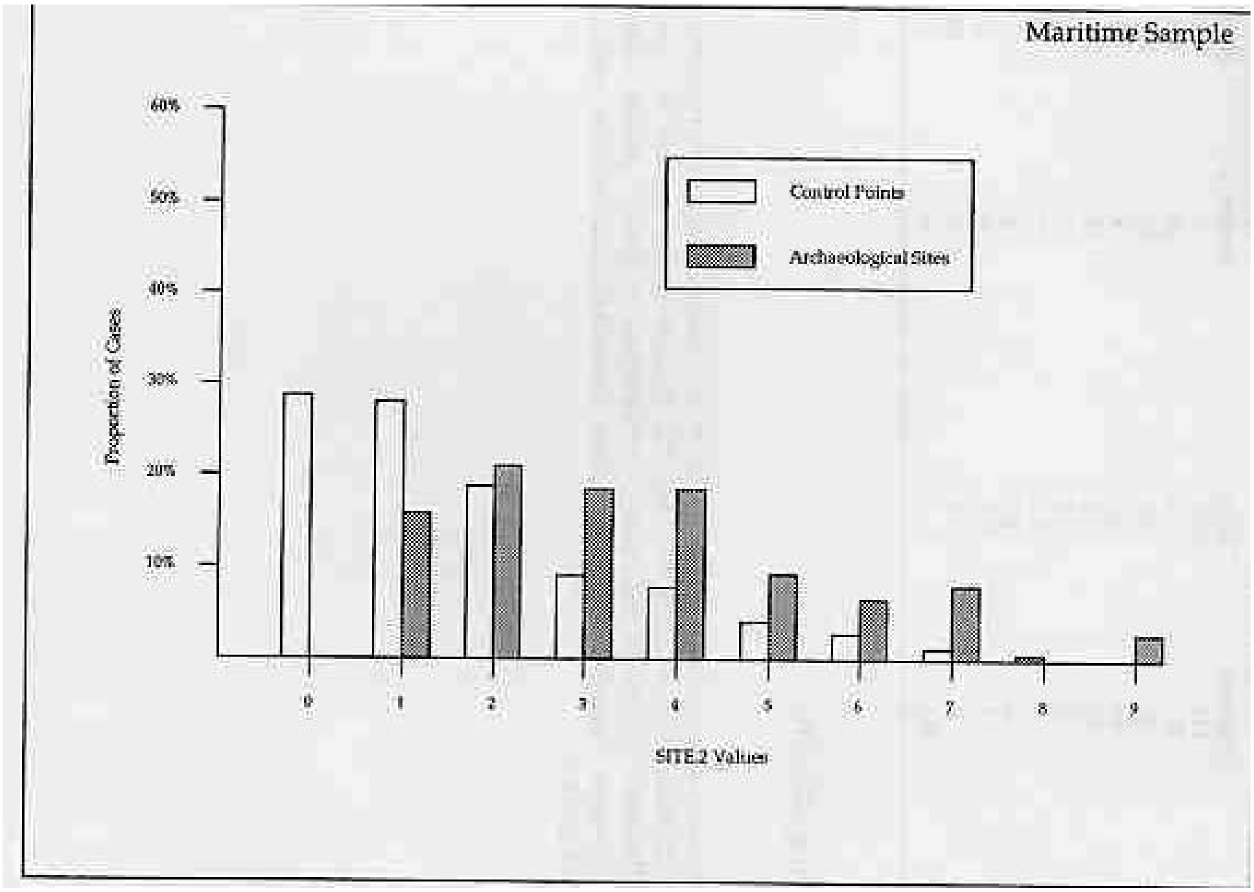


Figure 22. Distribution of variable SITE.2, Maritime Sample

Table 24. Frequency and percentage breakdowns for *SITE.2*, Maritime Sample.

	Control Points		Archaeological Sites
SITE.2	FrequencyPercent	Frequency	Percent
0	14128.7	0	0.0
1	13727.9	12	15.8
2	9218.7	16	21.1
3	449.0	14	18.4
4	377.5	14	18.4
5	193.9	7	9.2
6	132.7	5	6.6
7	61.2	6	7.9
8	20.4	0	0.0
9	00.0	2	2.6
Total	491	76	

Concluding Remarks

The next chapter will present the steps taken in the construction of the predictive models for site location. This will include an elaboration of some of the patterns discussed in this chapter using correlational analysis, a presentation of the multiple regression analyses used to generate the models, and consider some tests of the derived models.

VII. Predictive Models

This chapter will present the steps taken in constructing the predictive models of archaeological site location for the Charleston Harbor Project. The approach we chose for this purpose was a multivariate statistical analysis known as multiple regression. Multiple regression is an extension of the concepts surrounding simple regression, which endeavors to predict the values of one variable by reference to the values of another. The ideal relationship described by the model is linear and stipulates that for every incremental increase or decrease in a fixed independent variable, there will be a proportional and incremental increase or decrease in a dependent variable. The dependent variable is the variable we wish to predict given known values of the independent variable, commonly referred to as the predictor variable. Multiple regression considers simultaneously the effects of a number of independent variables on a dependent variable. This is a particularly good technique to use when the researcher is presented with complex relationships that cannot be satisfactorily explained by simpler, single-variable models. Certainly this is the case for the problem of predicting archaeological site location since archaeological sites vary in cultural affiliation, function, and time; and we can reasonably expect this variation to be responsive to different variables.

The first section of this chapter will present a brief overview of regression analysis and the special basis for multiple regression. The second section will review correlational relationships among the variables in the data base. The next section will describe the multiple regression models we derived from this analysis and the final section will test the veracity of the models by applying them to surveyed project areas not included in the original data bases that have known site distributions.

Fundamentals of Regression

Regression is a method whereby the relationship between a dependent and an independent variable is expressed as a linear equation. Relationships of this sort require that variables be either ordinal (ie. ranked) or continuous quantitative measurements (ie. weight, length, distance, etc.). The relationship is illustrated by what is known as a scattergram. Cases are plotted on an x-y axis according to the associated values of the two variables for each case. A perfect positive regression is one in which the scatter of points form a line that intercepts the y-axis at 0 and there is an equal increase or decrease in the dependent variable for every increase or decrease in the independent variable. The point at which the regression line intercepts the y-axis is called the *Intercept*. The line would extend in a 45° angle outward and bisect the area of the x-y axis in a perfect regression (Figure 23). The angle or relative steepness of the line is referred to as the *Slope*. These two measures are expressed as coefficients in regression equations and form the basis for predicting values of the dependent variable. The regression equation takes the following form: $y = a + bx$, where y is the dependent variable, a is the intercept coefficient, also known as the constant, b is the *slope coefficient*, and x is the value of the independent variable.

It is rare, however, to find real world situations in which the relationship between two variables is a perfect linear regression. Instead, the scatter of points is often curved or non-linear, the slope is flatter or steeper than a 45° angle, and the intercept does not run through the 0 point of the axis. In these cases the intercept and slope are calculated as linear relationships and the deviations (ie. residuals) of the points in the scattergram around this theoretical regression line are summed to produce a measurement of the standard error (*e*). The square root of the standard error is the standard deviation of the relationship. This statistic can be plotted as a band on either side of the regression line and contains 67 percent of the cases in the regressed sample. Strong regressions will characteristically have small standard errors, while poor ones will have large errors.

A statistic that measures the success of a regression is called the *coefficient of determination*, or R^2. This coefficient represents the fraction of the variability in the dependent variable that is explained or accounted for by the independent variable. Thus, an R^2 value of .76 would indicate that 76 percent of the variability in the dependent variable is explained by the independent variable. R^2 is expressed as values between 0 and 1. A value of 0 means that the independent (x) variable is not of use in predicting the dependent variable (y), while a value of 1 indicates a perfect linear prediction of y by x.

Multiple Regression extends the principles of the simple linear regression model to include more than one predictor variable. The effects of each predictor variable are considered to be additive in accounting for the variability in y. The equation takes the following form for p predictors: $y = a_0 + b_1 x_1 + b_2x_2 + ... + b_px_p$. Similarities to the simple regression equation are readily identifiable; a_0 is *the intercept coefficient* or constant and the remaining complex expressions represent the set of independent variables and their associated *slope coefficients*. The predictors are straight-forwardly summed and contain no other functions, hence the term @linear? equation is applied to this model. An important detail to appreciate with multiple regression, however, is that each slope coefficient is calculated after the linear effects of the other variables are accounted for in the equation. Thus, the relative contribution of a particular independent variable in explaining a dependent variable will change with changes in the composition of the set of independent variables used in the equation. R^2 is calculated as a measure of the success of a multiple regression equation as well. For those desiring additional information concerning this topic, excellent discussions of regression analysis can be consulted in Blalock (1972:361-460) and Ott (1984:391-444).

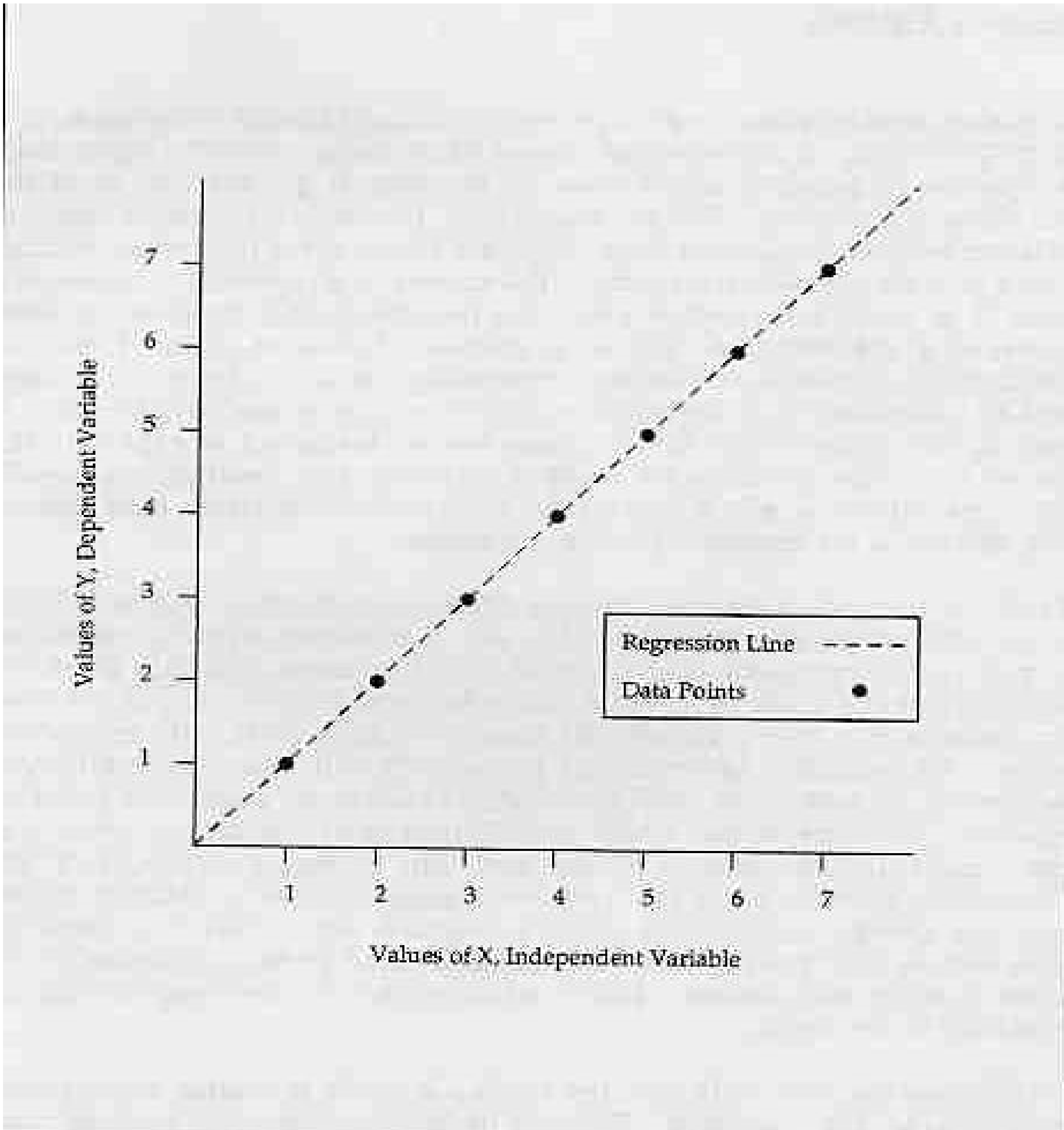


Figure 23. Scatterplot of perfect regression

Correlational Analysis

A statistic closely related to R^2 is Pearson=s Product-Moment Correlation, or *r* (Blalock 1972:376-385). It measures the degree of deviation around a linear least squares equation (regression) and informs on the general goodness of fit of the described linear relationship. R^2 is the square of *r*. Pearson=s *r*, in simple terms, is the correlation between the observed and predicted values of the dependent variable and as such provides us with a measure of the success of a regression. Values of *r* range from -1 to 1, and this supplies a basis for determining the direction (positive or negative) of a relationship as well as its success. Values of -1 and 1 indicate perfect negative and positive correlations respectively, while a value of 0 indicates the complete independence of the variables (ie. the values of one variable are not influenced by the values of the other). Since we are interested in exploring the goodness of fit of the variables for possible inclusion in a multiple regression analysis, *r* constitutes a much preferable means of comparison than simple regression and this is the method we use in this section.

Table 25 presents a Pearson Product-Moment correlation matrix for the primary variables of the Interior Sample data set. Correlation matrices contain all possible pairwise comparisons in a specified set of variables and this gives the characteristic triangular shape to the table. Since the correlation of x to y is the same as the correlation of y to x a rectangular matrix would express only redundant information. An inspection of the matrix in Table 25 will reveal predominantly weak correlations for both of the variables we wish to use as the dependent variables in our models. These are SITE.2, which we will refer to as site density when it is convenient, and SITEd, distance to nearest site. The strongest correlation in the matrix is actually between these two variables, indicating that as distance to site decreases, site density increases at a fairly constant rate. This is a negative correlation and as such the two variables will be related to the remainder of the variable set in an inverse manner. This is made evident by observing the sign of each correlation in the matrix.

SITE.2 is related positively with the various diversity measures and distance to nearest drainage rank 3 soil type. Thus site density increases with increased soil patch diversity and with increased distances to drainage rank 3 soils. On the other hand, distance to nearest stream (STd) and distance to drainage rank 1 and 2 soils decreases as site density increases. Thus, sites are more prevalent near drainage rank 1 and 2 soils and also near streams. Moreover, site density increases with decreases in associated soil patch; that is, site density increases with better drained soils. The variable INT, or interface type, is also negatively correlated with site density. It will be remembered that this variable was ranked according to our own assumptions about the type of interfaces that would be optimal for site location. Ecotonal interfaces were assigned a value of 1, dry interfaces were assigned a value of 2, and wet interfaces, which were regarded as the least optimal, were assigned a value of 3. Thus, there is an association between ecotonal and dry interfaces and greater site densities. SITEd is related to all of these variables in an inverse manner, as we would expect, because shorter distances to sites indicate a greater site density.

Table 25. Correlation (*r*) matrix of variables, Interior Sample.

	SITE.2	SITEd	STd	Hx	H.30	H.20	H.10	H.05	DR5	DR4	DR3	DR2	DR1	INT	NEAR	DRO
SITE.2	1.00															
SITEd	-0.58	1.00														
STd	-0.14	0.14	1.00													
Hx	0.22	-0.19	0.02	1.00												
H.30	0.21	-0.17	-0.02	0.79	1.00											
H.20	0.21	-0.15	0.04	0.87	0.75	1.00										
H.10	0.16	-0.14	0.04	0.83	0.44	0.59	1.00									
H.05	0.10	-0.13	0.01	0.69	0.26	0.36	0.64	1.00								
DR5	-0.09	0.02	-0.15	-0.38	-0.45	-0.36	-0.24	-0.14	1.00							
DR4	0.04	-0.01	-0.06	-0.21	-0.11	-0.17	-0.21	-0.19	-0.22	1.00						
DR3	0.22	-0.18	-0.06	-0.09	0.00	-0.05	-0.14	-0.10	-0.15	0.07	1.00					
DR2	-0.27	0.20	0.10	-0.37	-0.47	-0.36	-0.20	-0.13	0.21	-0.24	-0.21	1.00				
DR1	-0.24	0.16	0.25	-0.39	-0.49	-0.37	-0.19	-0.17	0.12	-0.09	-0.27	0.57	1.00			
INT	-0.39	0.30	0.16	-0.24	-0.33	-0.24	-0.11	-0.07	0.20	-0.25	-0.39	0.51	0.40	1.00		
NEAR	-0.09	0.08	0.03	-0.47	-0.15	-0.27	-0.52	-0.58	0.08	0.13	0.14	0.06	0.07	0.04	1.00	
DRO	-0.24	0.22	0.14	-0.07	-0.15	-0.09	-0.03	0.06	-0.02	-0.27	-0.19	0.33	0.27	0.49	-0.07	1.00

Examining other variable relationships in Table 25, we note that the diversity measures are highly correlated. They are, in fact, variably autocorrelated as they are computationally interdependent. That is, the calculation of each involves an additive input from the others. The diversity variable of least interdependence is H.05, which does not rely on the others for its measurement. In multiple regression it is imperative that variables of high interdependence be segregated and as such it would not be proper to use these variables, at least those other than H.05, in the same equation.

The non-site relationships provide a basis for understanding the structure of the environment. Nearly all diversity variables are related negatively to soil interface distance variables. We would expect this to be true because distances to different soil patch drainage ranks will decrease as the number of soil patches in a given search radius increases. DR1 and DR2 exhibit a fairly high positive correlation, indicating that they tend to occur together, since an increase in one is accompanied by a fairly regular increase in the other. DR2 is negatively correlated with DR3 and DR4, indicating that drainage ranks 3 and 4 occur away from soil patches of drainage rank 2, although these correlations are fairly weak. Interface type (INT) is positively correlated with DR1 and DR2 and negatively correlated with DR3 and DR4. This is not particularly meaningful because these variables are interdependent. Wet interfaces require soils of drainage ranks 3, 4, and 5, while dry ones require the presence of drainage ranks 1 and 2. Distance to nearest soil interface, NEAR, is not correlated with the soil drainage rank variables, but is negatively correlated with the diversity variables. We would expect this because soil interface distances should decrease with increased soil patch diversity. Distance to nearest stream, STd, exhibits very low correlations across the board.

A number of factors may contribute to the relatively low correlations we see in Table 25. Two factors, in particular, which appear to contribute to this are non-linear distributions and scale differences. One method of correcting for non-linear distributions is provided by an alternative correlation statistic called Spearman=s Rho, or rank order correlation coefficient (Blalock 1972:416-418). This is a non-parametric statistic that evaluates trends of association by transforming continuous data into rank groupings, thereby diminishing the effects of individual, low level deviations. Table 26 presents a Spearman=s rank correlation matrix for the Interior Sample. We can see that the correlations are generally strengthened by this analysis. However, the problem with using ranked data transformations in a model that we wish to standardize for common applications is that there is no set method for forming the ordinal groupings. We used a statistical package called DATA DESK to automatically form data ranks, but there is no guarantee that other statistical packages will form ranks in precisely the same manner.

Another method of smoothing and scaling data is logarithmic transformation. After some experimentation we arrived at the conclusion that a LOG10 transformation produced the highest correlations and these are presented in Table 27. These transformed variables are identified with the prefix @L? to differentiate them from the raw variables. As we see, these log transformations produce correlations of the same order as Spearman=s Rho. Both are an improvement over the raw variable correlations.

Tables 28 and 29 present Pearson=s Product-Moment Correlation (*r*) matrices for the raw and transformed LOG10 variables of the Maritime Sample. Again we see that the correlations are generally low and are improved by LOG10 transformations. SITE.2 and SITEd show the same strong negative correlation as we saw for the Interior Sample. Again we see that site density (SITE.2) is positively correlated with the diversity variables and is negatively correlated with most of the soil drainage rank distance variables. Especially strong are the correlations with DR2 and DR3. There is very little relationship between the distances to the poorer drained soils (ie. DR4, DR5, and DR6) and site density. Distance to nearest soil interface (NEAR) presents a fairly high correlation for both site variables. This is also true for DR0.

Table 26. Spearman's rank correlation (Rho) matrix of variables, Interior Sample.

	SITE.2	SITEd	STd	Hx	H.30	H.20	H.10	H.05	DR5	DR4	DR3	DR2	DR1	INT	NEAR	DRO
SITE.2	1.00															
SITEd	-0.58	1.00														
STd	-0.14	0.14	1.00													
Hx	0.22	-0.19	0.02	1.00												
H.30	0.21	-0.17	-0.02	0.79	1.00											
H.20	0.21	-0.15	0.04	0.87	0.75	1.00										
H.10	0.16	-0.14	0.04	0.83	0.44	0.59	1.00									
H.05	0.10	-0.13	0.01	0.69	0.26	0.36	0.64	1.00								
DR5	-0.09	0.02	-0.15	-0.38	-0.45	-0.36	-0.24	-0.14	1.00							
DR4	0.04	-0.01	-0.06	-0.21	-0.11	-0.17	-0.21	-0.19	-0.22	1.00						
DR3	0.22	-0.18	-0.06	-0.09	0.00	-0.05	-0.14	-0.10	-0.15	0.07	1.00					
DR2	-0.27	0.20	0.10	-0.37	-0.47	-0.36	-0.20	-0.13	0.21	-0.24	-0.21	1.00				
DR1	-0.24	0.16	0.25	-0.39	-0.49	-0.37	-0.19	-0.17	0.12	-0.09	-0.27	0.57	1.00			
INT	-0.39	0.30	0.16	-0.24	-0.33	-0.24	-0.11	-0.07	0.20	-0.25	-0.39	0.51	0.40	1.00		
NEAR	-0.09	0.08	0.03	-0.47	-0.15	-0.27	-0.52	-0.58	0.08	0.13	0.14	0.06	0.07	0.04	1.00	
DRO	-0.24	0.22	0.14	-0.07	-0.15	-0.09	-0.03	0.06	-0.02	-0.27	-0.19	0.33	0.27	0.49	-0.07	1.00

Table 27. Correlation (r) matrix of transformed Log10 variables, Interior Sample.

	LSITE.2	LSITEd	LSTd	LHx	LH.30	LH.20	LH.10	LH.05	LDR5	LDR4	LDR3	LDR2	LDR1	LINT	LNEAR	LDRO
LSITE.2	1.00															
LSITEd	-0.63	1.00														
LSTd	-0.15	0.11	1.00													
LHx	0.23	-0.20	-0.10	1.00												
LH.30	0.22	-0.19	-0.07	0.79	1.00											
LH.20	0.21	-0.14	-0.05	0.86	0.72	1.00										
LH.10	0.16	-0.13	-0.09	0.80	0.38	0.55	1.00									
LH.05	0.11	-0.13	-0.11	0.65	0.23	0.33	0.63	1.00								
LDR5	-0.09	0.06	-0.08	-0.44	-0.37	-0.35	-0.32	-0.31	1.00							
LDR4	0.12	-0.11	0.07	-0.12	0.04	-0.04	-0.16	-0.24	-0.16	1.00						
LDR3	0.25	-0.18	-0.07	0.07	0.20	0.10	-0.05	-0.06	-0.21	-0.09	1.00					
LDR2	-0.32	0.29	0.10	-0.27	-0.35	-0.25	-0.12	-0.08	0.09	-0.43	-0.52	1.00				
LDR1	-0.26	0.21	0.15	-0.40	-0.43	-0.38	-0.23	-0.18	0.03	-0.09	-0.37	0.13	1.00			
LINT	-0.37	0.30	0.19	-0.23	-0.30	-0.22	-0.10	-0.06	0.16	-0.24	-0.63	0.69	0.36	1.00		
LNEAR	-0.15	0.19	0.11	-0.48	-0.16	-0.25	-0.52	-0.68	0.33	0.25	0.10	0.07	0.11	0.05	1.00	
LDRO	-0.28	0.33	0.06	-0.13	-0.20	-0.15	-0.06	0.03	-0.18	-0.45	-0.31	0.51	0.59	0.49	-0.04	1.00

Correlations of the environmental variables point to structural patterns in the coastal ecosystem. Diversity variables are negatively correlated with distances to most drainage rank variables. The highest correlations occur with the better drained soils (ie. DR1, DR2, and DR3). The exception is DR6, which is positively correlated with diversity. This indicates that distance to salt marsh increases with increased diversity. This pattern is primarily a function of measuring control points well out into the marsh, resulting in a number of low diversity points represented almost solely by salt marsh soils. Distance to nearest soil interface, NEAR, is highly correlated with diversity, especially mean diversity (Hx). Distance to nearest stream, STd, is poorly correlated with diversity and most soil drainage rank variables. It has a high negative correlation with DR5, which is expected because this drainage rank is associated with creek bottom soils. NEAR is positively correlated with DR0, indicating that as distance to nearest soil interface decreases, so does the drainage rank of the associated soil type.

Table 28. Correlation (r) matrix of variables, Maritime Sample.

	Site.2	Site d	STd	Hx	H.30	H.20	H.10	H.05	DR6	DR5	DR4	DR3	DR2	DR1	INT	Near
Site.2	1.00															
Site d	-.66	1.00														
STd	-.09	.15	1.00													
Hx	.33	-.38	.16	1.00												
H.30	.26	-.28	.22	.80	1.00											
H.20	.32	-.37	.17	.88	.74	1.00										
H.10	.27	-.34	.05	.83	.43	.60	1.00									
H.05	.20	-.25	.04	.70	.30	.40	.66	1.00								
DR6	-.21	.14	.37	.14	.23	.14	.04	.03	1.00							
DR5	-.08	.02	-.47	-.46	-.60	-.46	-.23	-.14	-.45	1.00						
DR4	.07	.12	-.09	-.41	-.19	-.32	-.42	-.42	-.18	-.11	1.00					
DR3	-.25	.16	-.33	-.54	-.65	-.54	-.30	-.17	-.39	.85	-.18	1.00				
DR2	-.21	.34	-.14	-.71	-.56	-.63	-.60	-.49	-.22	.28	.33	.36	1.00			
DR1	.16	.00	.00	-.44	-.49	-.38	-.29	-.23	-.23	.32	.17	.30	.31	1.00		
INT	-.08	.12	-.04	-.23	-.19	-.20	-.16	-.21	-.09	.14	-.07	.18	.52	.32	1.00	
Near d	-.25	.38	-.01	-.64	-.40	-.49	-.60	-.62	-.13	.07	.65	.09	.50	.23	.03	1.00
DR0	-.20	.32	-.09	-.53	-.40	-.45	-.43	-.41	-.39	.29	.30	.37	.55	.33	.39	.41

Another factor that depresses the correlations in the data sets is the reliability of the site data. There is a problem of accuracy at the borders of the survey areas, as we discussed previously, and we developed a variable, Coverage Radius (CR), to help control for this potential source of error. The underlying assumption here is that as coverage radius increases, so does confidence in our ability to measure site density (SITE.2) and nearest distance to site (SITEd). The site distributions along the margins of the surveyed areas are unknown and hence we are less certain of the actual site densities at locations with smaller coverage radii. Tables 30 through 33 display the progression of correlations on these variables for specified coverage radii. The coverage radii cut-offs we selected for the Interior Sample were .25, .30, .35, .40, and .45 miles, while the Maritime cut-offs were .30, .60, .90, and 1.20 miles. As can be seen, the correlations improve with larger radii and this suggests that a more precise and accurate model can be generated from subsamples of the data bases in which the points with smaller coverage radii are eliminated.

An examination of the tables, and Figures 24 and 25, indicate that certain thresholds exist in these progressions. In the case of the Interior Sample, the correlation coefficients generally level off at a coverage radius of .35 miles. There is a substantial difference between the .30 subsample and the .35 sample and although there are cases where the correlations advance in the .40 and .45 mile subsamples, the differences are slight and do not compensate for the reduced sample sizes we would encounter if we chose these larger radii for modelling. In the case of the Maritime Sample, the cut-off would appear to be positioned at a coverage radius between about .60 and .90 miles. A problem with relying on the larger coverage radii in the Maritime Sample is that they become increasingly biased by remote salt marsh control points. In addition, the Maritime Sample is much smaller and

Table 29. Correlation (r) matrix of transformed Log10 variables, Maritime Sample.

	LSITE.2	LSITEd	LSTd	LHx	LH.30	LH.20	LH.10	LH.05	LDR6	LDR5	LDR4	LDR3	LDR2	LDR1	LINT	LNEAR
LSITE..2	1.00															
LSITE d	-.59	1.00														
LSTd	-.17	.23	1.00													
LHx	.39	-.30	.05	1.00												
LH.30	.31	-.18	.08	.83	1.00											
LH.20	.38	-.27	.07	.89	.76	1.00										
LH.10	.32	-.30	.01	.81	.45	.61	1.00									
LH.05	.23	-.23	.00	.67	.32	.41	.66	1.00								
LDR6	-.04	.08	.39	.33	.36	.32	.22	.15	1.00							
LDR5	.03	-.08	-.36	-.37	-.45	-.35	-.19	-.13	-.41	1.00						
LDR4	.09	-.01	-.09	-.19	-.04	-.12	-.24	-.31	-.32	-.13	1.00					
LDR3	-.20	.12	-.19	-.38	-.43	-.36	-.24	-.14	-.42	.50	-.32	1.00				
LDR2	-.23	.26	-.11	-.54	-.40	-.44	-.47	-.46	-.34	.10	.01	.03	1.00			
LDR1	-.06	.06	.09	-.40	-.37	-.34	-.29	-.27	-.20	.09	.06	-.04	.16	1.00		
LINT	-.08	.11	-.05	-.18	-.14	-.15	-.12	-.19	-.19	-.02	.00	-.20	.61	.32	1.00	
LNEAR	-.27	.39	.07	-.53	-.27	-.35	-.54	-.69	-.03	.06	.37	.13	.39	.20	.08	1.00
LDR0	-.24	.30	-.11	-.51	-.40	-.44	-.43	-.41	-.57	.18	.01	.28	.64	.52	.41	.35

the largest coverage radii entail too drastic a reduction in sample size. A cut-off of .60 miles would appear to be an acceptable compromise since the disparity in sample size between the .60 mile and that of the .90 mile subsamples is respectively 292 cases to 175 cases.

Table 30. Progression of correlations by coverage radius (CR) for LSITE.2 and environmental variables, Interior Sample

	LSITE.2(All)	LSITE.2 (.25)	LSite.2 (.30)	LSite.2 (.35)	LSite.2 (.40)	LSite.2(.45)
LSITE.2	1.00	1.00	1.00	1.00	1.00	1.00
LSITEd	-.63	-.69	-.71	-.75	-.77	-.76
LSTd	-.15	-.25	-.27	-.23	-.21	-.20
LHx	.23	.36	.42	.50	.50	.50
LH.30	.22	.30	.35	.45	.48	.47
LH.20	.21	.31	.37	.44	.45	.43
LH.10	.16	.28	.32	.36	.35	.35
LH.05	.11	.25	.29	.33	.29	.32
LDR5	-.09	-.15	-.19	-.21	-.22	-.18
LDR4	.12	.25	.28	.29	.33	.32
LDR3	.25	.27	.26	.25	.22	.17
LDR2	-.32	-.50	-.54	-.57	-.56	-.53
LDR1	-.26	-.32	-.33	-.34	-.34	-.34
LINT	-.37	-.51	-.51	-.55	-.54	-.51
LNEAR	-.15	-.26	-.29	-.31	-.27	-.26
LDRO	-.28	-.43	-.46	-.51	-.50	-.51

Table 31. Progression of correlations by coverage radius (CR) for LSITEd and environmental variables, Interior Sample

	LSITEd(All)	LSITE.d (.25)	LSite d (.30)	LSite d(.35)	LSite d(.40)	LSite d (.45)
LSITEd	1.00	1.00	1.00	1.00	1.00	1.00
LSTd	.11	.18	.16	.21	.20	.18
LHx	-.20	-.32	-.38	-.45	-.47	-.46
LH.30	-.19	-.29	-.35	-.44	-.48	-.47
LH.20	-.14	-.24	-.29	-.33	-.35	-.33
LH.10	-.13	-.26	-.29	-.33	-.34	-.33
LH.05	-.13	-.23	-.25	-.32	-.29	-.31
LDR5	.06	.07	.07	.08	.07	.05
LDR4	-.11	-.25	-.29	-.28	-.30	-.28
LDR3	-.18	-.17	-.14	-.16	-.10	-.09
LDR2	.29	.47	.51	.56	.53	.50
LDR1	.21	.28	.32	.34	.34	.33
LINT	.30	.40	.41	.49	.45	.42
LNEAR	.19	.27	.29	.32	.30	.28
LDRO	.33	.49	.56	.55	.54	.52

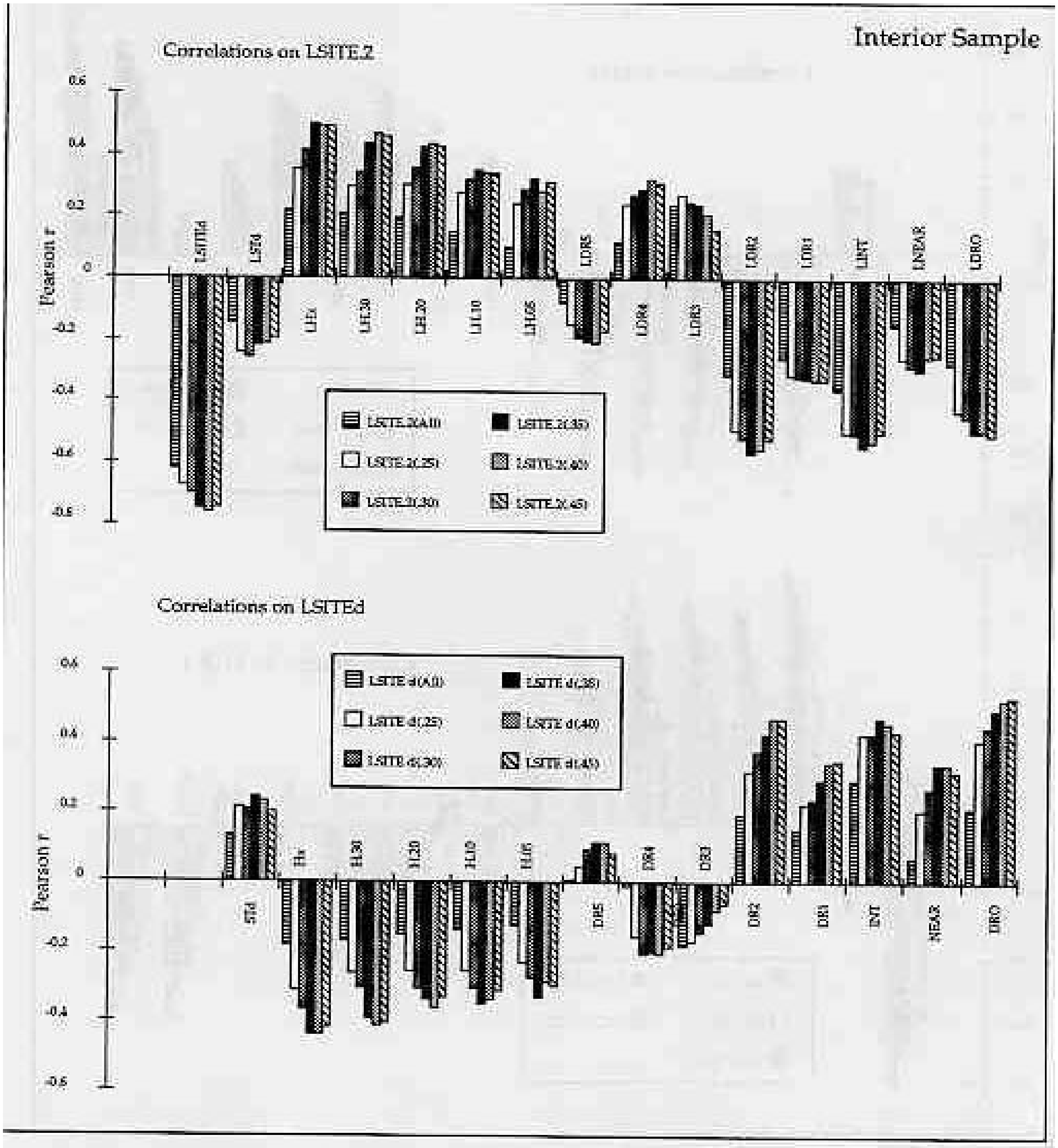


Figure 24. Progression of correlation coefficients (r) for coverage radii, Interior Sample

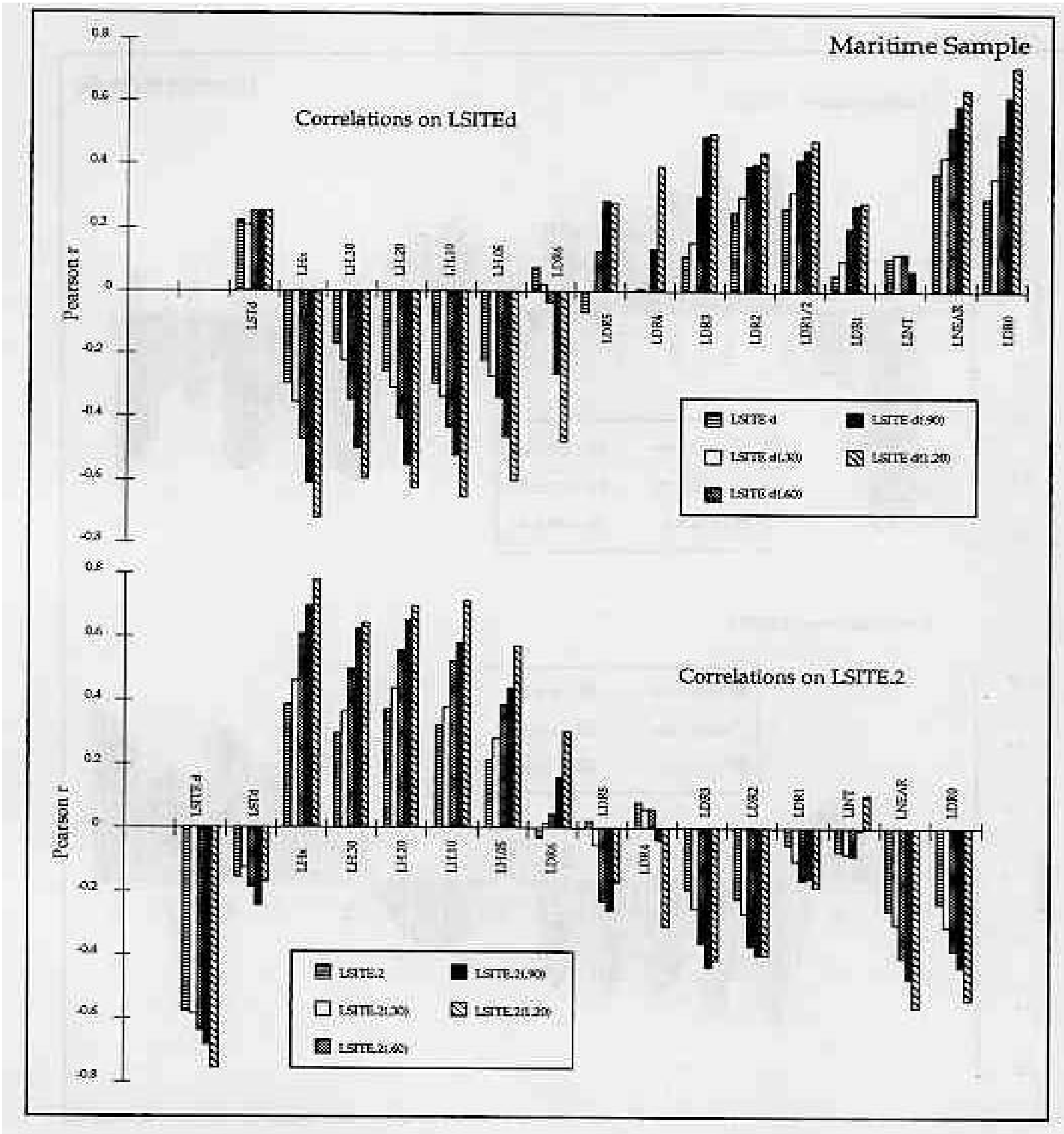


Figure 25. Progression of correlation coefficients (r) for coverage radii, Maritime Sample

The preceding analysis has provided the reader with a fundamental awareness of the variable relationships and limitations of the data sets. It has also outlined some of the special techniques applied to this data base to prepare it for multiple regression analysis. A LOG10 transformation of the data smoothed the effects of non-linear distributions and scale differences in the structure of the variables. Moreover, elimination of lower confidence cases greatly increased the strength of the correlations. The pairwise correlations are, in general, flatter than perfect correlations and as such a relatively large amount of deviation around the regression line is extant. This does not mean, however, that the variables are not useful in predicting site location, only that we must accept a large error range. This is to be expected in a complex problem like the one on which this study focuses. Multiple regression can reduce this overall variability by combining the effects of a number of independent variables simultaneously. The next section will lay out the steps taken in the generation of the predictive equations for modelling site location in the Charleston Harbor watershed.

Table 32. Progression of correlations by coverage radius (CR) for LSITE.2 and environmental variables, Maritime Sample.

	LSite.2	LSite.2(.30)	LSite.2(.60)	LSite.2(.90)	LSite.2(1.20)
LSite.2	1.00	1.00	1.00	1.00	1.00
LSite d	-.59	-.59	-.64	-.69	-.76
LSTd	-.17	-.14	-.20	-.25	-.18
LHx	.39	.47	.62	.71	.79
LH.30	.31	.37	.51	.63	.66
LH.20	.38	.44	.57	.67	.71
LH.10	.32	.39	.53	.59	.72
LH.05	.23	.29	.39	.44	.58
LDR6	-.04	.02	.05	.16	.32
LDR5	.03	-.06	-.24	-.27	-.18
LDR4	.09	.07	.07	-.05	-.32
LDR3	-.20	-.26	-.37	-.44	-.42
LDR2	-.23	-.28	-.38	-.41	-.41
LDR1	-.06	-.11	-.17	-.16	-.20
LINT	-.08	-.09	-.10	-.02	.11
LNear d	-.27	-.31	-.41	-.48	-.57
LDR0	-.24	-.32	-.39	-.45	-.55

Table 33. Progression of correlations by coverage radius (CR) for LSITEd and environmental variables, Maritime Sample.

	LSite d(All)	LSite d(.30)	LSite d(.60)	LSite d(.90)	LSite d(1.20)
LSite d	1.00	1.00	1.00	1.00	1.00
LSTd	.23	.21	.25	.26	.25
LHx	-.30	-.36	-.48	-.62	-.73
LH.30	-.18	-.23	-.35	-.51	-.60
LH.20	-.27	-.31	-.41	-.56	-.63
LH.10	-.30	-.35	-.44	-.53	-.66
LH.05	-.23	-.28	-.35	-.47	-.61
LDR6	.08	.03	-.05	-.28	-.49
LDR5	-.08	-.01	.13	.30	.28
LDR4	-.01	.01	-.01	.14	.40
LDR3	.12	.16	.31	.50	.51
LDR2	.26	.31	.40	.41	.45
LDR1/2	.27	.32	.42	.46	.49
LDR1	.06	.11	.20	.28	.29
LINT	.11	.12	.12	.07	-.01
LNear d	.39	.43	.53	.60	.64
LDR0	.30	.37	.51	.62	.72

Multiple Regression Models

A series of multiple regression trial runs were made to determine the best-fit combination of variables for constructing model equations for the Interior and Maritime Samples. The variables with the greatest predictive value were anticipated from the associational and correlational analyses we discussed above, although determining the optimal mix required experimentation. Some statistical packages provide an option known as *stepwise regression* which automatically builds a regression model through the addition or deletion of predictor variables according to statistical thresholds. The package we used, DATA DESK, does not provide this option. However, this was not a major problem with the data sets we constructed since the relationships were rather simple and intuitively obvious.

Separate models were generated for a number of different subsamples based on coverage radius cut-off points as described in the last section. An expected result was that as coverage radius increased and sample size decreased, R^2 increased. Figure 26 illustrates the trend in Adjusted R^2 values for the various best-fit solutions at a given coverage radius. Values increase from about 17 percent to slightly more than 46 percent in the Interior Sample and level off at a coverage radius of 0.35 miles. Values increase from about 25 to 68 percent for the Maritime Sample, but continue to climb with increased coverage radius. There is no leveling off.

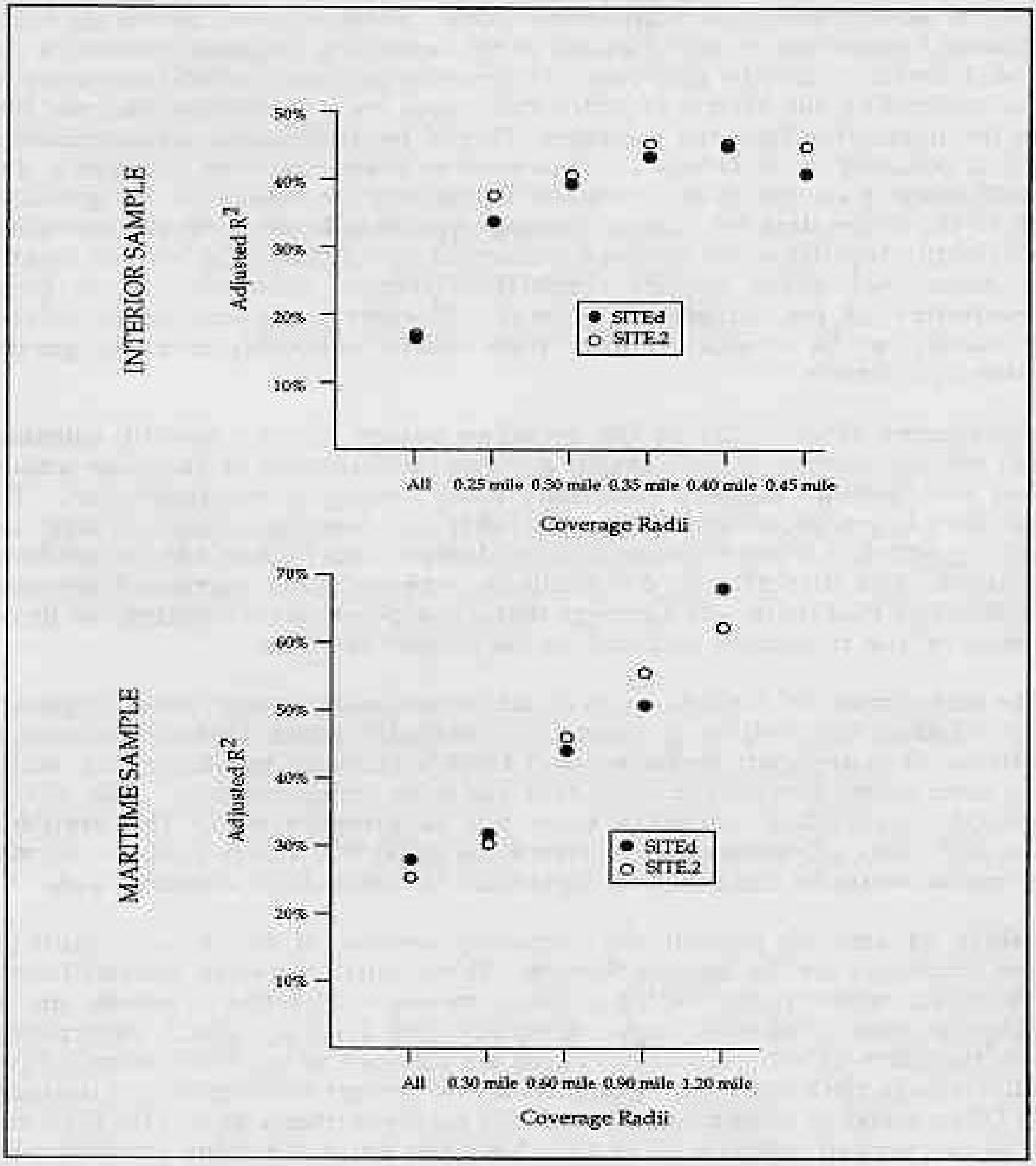


Figure 26. Progression of adjusted R^2 values for coverage radii

Once the best-fit solutions were generated the data bases were checked for extreme or aberrant cases. It is a characteristic of correlational analyses that they are disproportionately influenced by extreme values and this can result in the artificial weakening or strengthening of a true relationship. Extreme cases can be identified by examining histograms of each variable or by examining diagnostic statistics that can be calculated on a case by case basis. Diagnostics provide a much more effective means of evaluating the effects of individual cases on a regression because they factor in the interaction between variables. One of the diagnostics we examined in this light is referred to as *Leverage*. This statistic measures how extreme a data point's influence is on the final regression by relating its values on the predictor variables to the entire data set. Larger leverage values indicate more extreme cases. A rule of thumb stipulates that leverage values above 0.5 should be used to identify extreme cases that might require elimination from a data set due to being unrepresentative of the sample in general. However, elimination of smaller leverage values can be considered when they deviate noticeably from the general distribution in a sample.

Histograms (Figure 27) of the leverage values for the best-fit solutions generated for the Interior Sample reveal a normal distribution of very low values, indicating that individual cases contribute fairly evenly to the regression. The Maritime Sample produced equations with fairly low leverage values as well, but there was a great deal more variation in their distributions (Figure 28). In addition, the magnitude and disparity in distributions increased with increased coverage radius, indicating that there was a danger that a few points were exerting too heavy an influence on the regression solutions in the smaller samples.

The same trends in the data bases could be seen using several other diagnostic statistics, including the plotting of studentized residuals, which identify extremes in the predicted or dependent variables, and Cook=s Distance measurement, which considers both dependent and independent variables simultaneously. The overall effects on the dependent variables were not as pronounced in the Maritime equations and Cook's Distance measurement indicated that either a .30 or .60 mile coverage radius could be used without significant influence from extreme cases.

Tables 34 and 35 present the summary reports of the best-fit multiple regression equations for the Interior Sample. These equations were derived from a subsample of all control points with a coverage radius of .35 miles or greater and all archaeological sites from the larger sample. The two equations incorporate essentially the same LOG10 variables. These are distance to nearest stream (LSTd), mean soil drainage rank diversity (LHx), distance to nearest soil interface of drainage rank 4 (LDR4), distance to nearest soil drainage rank of either 1 or 2 (LDR1/2), and distance to nearest soil interface (LNEAR). DR0 also has some value for predicting SITEd or LSITEd. LDR1/2 represents a derived variable combining the effects of the better drained soils. This was done to eliminate analytical noise due to the fact that DR1 patches are very spotty in distribution throughout the watershed. This created situations in which DR1 patches were located at great distances from a project area, even though when present in project areas they were generally situated very near sites and adjacent to DR2 soils. DR1/2 records the distance from either DR1 or DR2, whichever is closer.

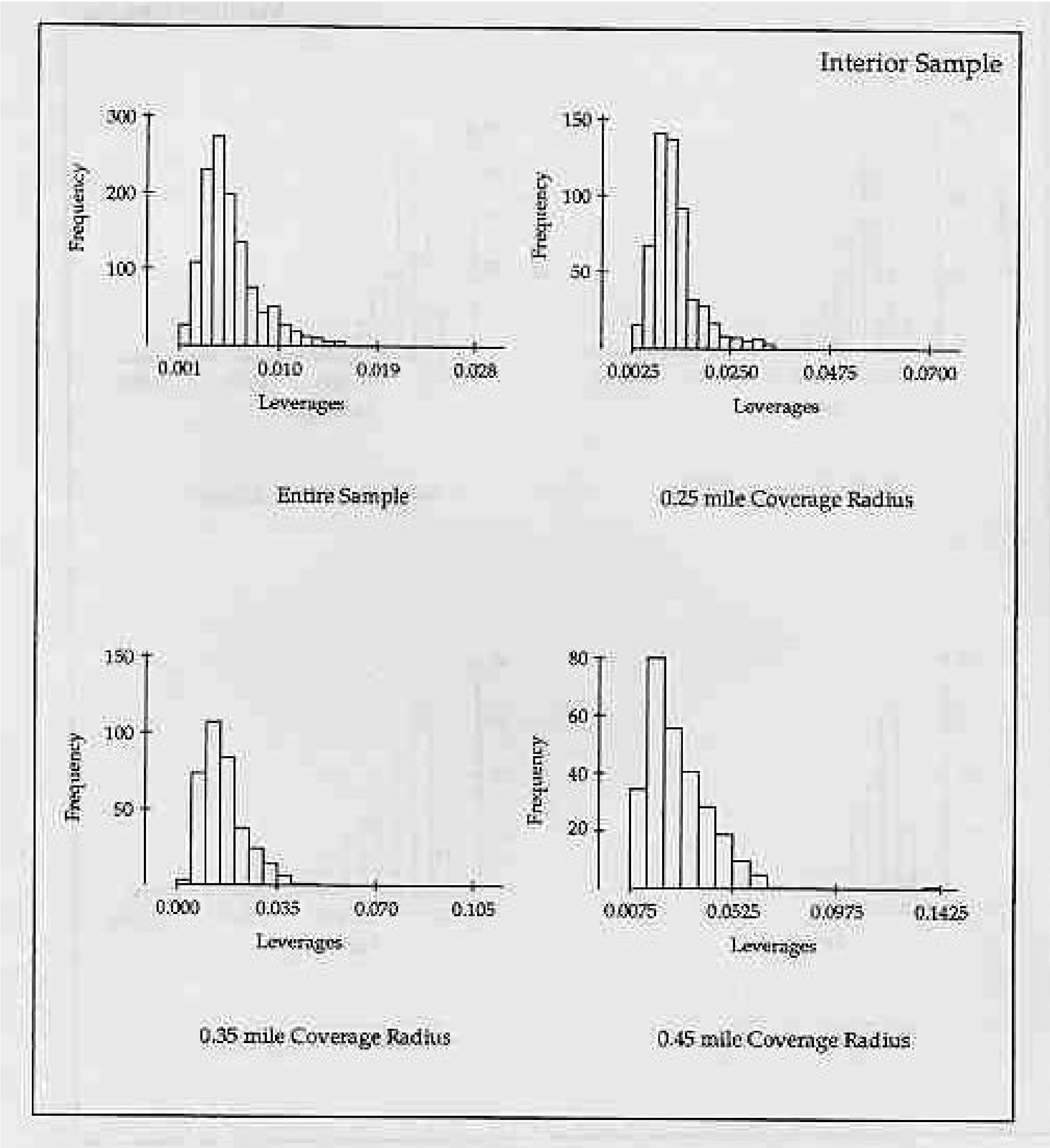


Figure 27. Histograms of leverage values, Interior Sample

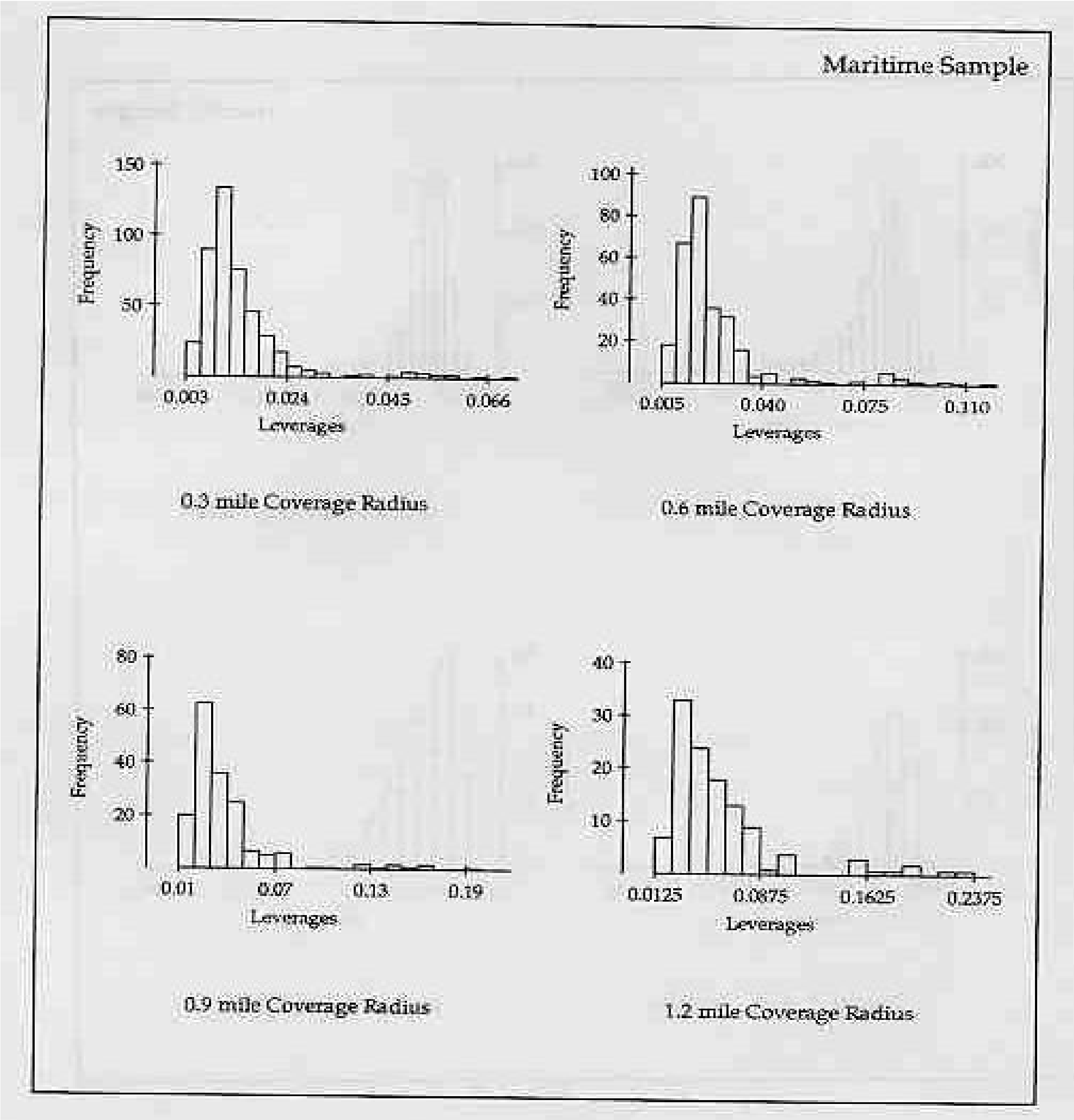


Figure 28. Histograms of leverage values, Maritime Sample

A regression summary table contains numerous kinds of statistical information to evaluate the effectiveness of the associated equation. The coefficient of determination, R^2, as we have noted, is an expression of the percent of the variability in the dependent variable explained by the equation. A quick reference to the tables will show that this value is actually the sum of squares of the regression divided by the total sum of squares (ie. for both the regression and residual sources). In the two equations presented here, R^2 explains only a little less than 50 percent of the variability in the two site variables. This is lower than we would have liked, but it should not be concluded that the equations are of little use to us. In fact, we will see in the next section that they perform fairly well in identifying areas of high and low site potential. There is obviously a large amount of the variability still unexplained and we have already mentioned some of the likely sources that would add definition to our model if we were to develop analytical programs to identify and control their measurement.

Table 34. Multiple regression summary table of LSITE.2 on LSTd, LHx, LDR4, LDR1/2, and LNEAR, Interior Sample.

Dependent variable is: LSITE.2
R^2 = 46.2% R^2 (adjusted) = 45.5%
s = 0.4137 with 360 - 6 = 354 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	52.1311	5	10.43	60.9
Residual	60.5902	354	0.171159	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-0.947954	0.0938	-10.1	
LSTd	-0.116274	0.0536	-2.17	
LHx	0.852889	0.2655	3.21	
LDR4	0.090858	0.0300	3.02	
LDR1/2	-0.191720	0.0233	-8.24	
LNEAR	-0.132135	0.0434	-3.05	

Table 35. Multiple regression summary table of LSITEd on LSTd, LHx, LDR4, LDR1/2, LNEAR, and LDRO, Interior Sample.

Dependent variable is: LSITE d
R^2 = 44.4% R^2 (adjusted) = 43.5%
s = 0.8933 with 360 - 7 = 353 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	225.066	6	37.5	47.0
Residual	281.674	353	0.797942	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-0.971604	0.3159	-3.08	
LSTd	0.189586	0.1160	1.63	
LHx	-0.971347	0.5751	-1.69	
LDR4	-0.161797	0.0652	-2.48	
LDR1/2	0.308267	0.0670	4.60	
LNEAR	0.362877	0.0942	3.85	
LDRO	1.20792	0.4363	2.77	

The F-ratio in the summary reports evaluates whether the overall regression is statistically significant. Consultation with standard F-distribution tables indicates that both of these regressions are significant at a probability of less than .01, given 6 and 354 and 7 and 353 degrees of freedom respectively. In other words, both regressions appear to reflect legitimate patterns of covariation.

The coefficients associated with each variable represent the unit of change for each independent variable relative to a unit change in the dependent variable, *after removing the linear effects of all other independent variables*. Each of these represents a *slope coefficient* as described for the simple regression model above. The constant is the *intercept coefficient* of that model. The *t*-ratios evaluate the statistical significance of each coefficient. All of the coefficients in these equations are significant at the .05 level of probability for a one-tailed *t*-test, with the exception of LSTd in the SITEd equation (Table 35). The critical *t*-ratio is 1.645 and the *t*-ratio for LSTd is just under this at 1.63. We decided to allow this variable to remain in the equation, however, because it was felt that the effects of stream proximity might increase the overall utility of the model. In general, then, all of the independent variables appear to influence the linear prediction of the dependent variables.

The resulting equations take the following form:

(1) LSITE.2 = -0.947954 + (-0.116274 x LSTd) + (0.852889 x LHx) + (0.090858 x LDR4) + (-0.19172 x LDR1/2) + (-0.132135 x LNEAR).

(2)LSITEd = -0.971604 + (0.189586 x LSTd) + (-0.971347 x LHx) + (-0.161797 x LDR4) + (0.308267 x LDR1/2) + (0.362877 x LNEAR) + (1.20792 x LDRO).

These equations represent the sum of the constant, or *intercept coefficient*, and the products of the variable coefficients and the LOG10 transformations of the variable values. For any measured control point or site, then, a predicted value of the LOG10 transformations of site density (LSITE.2) or distance to nearest site (LSITEd) can be calculated simply by plugging the variable values derived at that point into these equations.

Extrapolating from the variable relationships in the models, we can conclude the following about site location in the Interior stratum of the Charleston Harbor watershed. Archaeological sites will be found in greater densities in locations of high soil drainage rank diversity, near soil interfaces, especially at ecotonal interfaces between soil patches of drainage ranks 1 or 2 and 4. Nearness to streams factors into this equation as well, but it has only a weak influence on prediction.

Tables 36 and 37 contain the best-fit multiple regression equation summaries for the Maritime Sample. These were generated from a subsample of 292 cases consisting of all archaeological sites and those control points associated with a coverage radius of greater than or equal to 0.60 miles. The equations are again expressed in terms of LOG10 transformations. Both equations have R^2 values comparable to those derived for the Interior equations. Each explains a little less than half of the variability contained in the dependent variables (ie. LSITE.2 and LSITEd). Both are explained best by the same set of six independent variables. These include distance to nearest stream (LSTd), mean soil drainage rank diversity (LHx), soil drainage rank diversity at a search radius of 0.05 miles (H.05), distance to soil drainage ranks of 6 (LDR6) and 1 (LDR1), and soil drainage rank association (DR0). Although there is some interdependence between the calculations of mean diversity and .05 radius diversity, it was felt that the influence of each on site density was primarily independent, as the former characterizes immediate point diversity, while the other measures a broader catchment of diversity.

An evaluation of the components of the equations indicates that the independent variables strongly influence the prediction of site density and site proximity. The F-ratios are large and have associated probabilities of less than .01, which argues that there is little chance that the relationships stipulated in the model occur by chance. Moreover the *t*-ratios indicate significance at probability levels of .01 or less, which means that all of the independent variables exert significant influence in the prediction of the dependent variables. The multiple regression equations for the Maritime Sample can be expressed in the following form:

(1) LSITE.2 = -1.26294 + (-0.199682x LSTd) + (3.51543 x LHx) + (-0.508256 x LH.05) + (-0.185025 x LDR6) + (0.22531 x LDR1) + (-0.972209 x LDR0).

(2) LSITEd = -1.5015 + (0.446929 x LSTd) + (-2.92139 x LHx) + (-0.699786 x LH.05) + (0.346784 x LDR6) + (-0.427669 x LDR1) + (3.43849 x LDR0).

Table 36. Multiple regression summary table of LSITE.2 on LSTd, LHx, LH.05 LDR6, LDR1, and LDRO, Maritime Sample.

Dependent variable is: LSite.2
292 total cases of which 2 are missing
R^2 = 47.3% R^2 (adjusted) = 46.2%
s = 0.4777 with 290 - 7 = 283 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	57.9487	6	9.658	42.3
Residual	64.5847	283	0.228214	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-1.26294	0.2113	-5.98	
LSTd	-0.199682	0.0587	-3.40	
LHx	3.51543	0.3288	10.7	
LH.05	-0.508256	0.2101	-2.42	
LDR6	-0.185025	0.0387	-4.78	
LDR1	0.225310	0.0628	3.59	
LDR0	-0.972209	0.2314	-4.20	

Table 37. Multiple regression summary table of LSITEd on LSTd, LHx, LH.05 LDR6, LDR1, and LDRO, Maritime Sample.

Dependent variable is: LSite d
292 total cases of which 2 are missing
R^2 = 45.4% R^2 (adjusted) = 44.3%
s = 0.7647 with 290 - 7 = 283 degrees of freedom

Source	Sum of Squares	df	Mean Square	F-ratio
Regression	137.673	6	22.9	39.2
Residual	165.480	283	0.584734	
Variable	Coefficient	s.e. of Coeff	t-ratio	
Constant	-1.50150	0.3383	-4.44	
LSTd	0.446929	0.0940	4.75	
LHx	-2.92139	0.5262	-5.55	
LH.05	0.699786	0.3362	2.08	
LDR6	0.346784	0.0619	5.60	
LDR1	-0.427669	0.1005	-4.26	
LDR0	3.43849	0.3704	9.28	

The implications of these equations are that archaeological sites on the coastal fringe of the Charleston Harbor watershed will be situated in locations of broad catchment soil drainage diversity, but also in locations where the immediate point diversity (LH.05) is low. This would suggest that sites will be situated on wide, well drained landforms adjacent to large, poorly drained soil patches. This locational principal is supported by the fact that locations of greater site density are associated with soils of lower drainage rank (ie. better drained soils). Moreover, site density will increase with proximity to salt marsh, which constitutes the highest proportion of poorly drained soils adjacent to well drained landforms. Distance to streams would also appear to have a greater influence on site densities than it did in the Interior Sample.

It is quite obvious from an inspection of the equations for both the Interior and Maritime Samples that the two dependent variables, LSITE.2 and LSITEd, have very similar solutions. The same independent variables are used and the corresponding coefficients for each are of relatively equal magnitude. In fact, if we generate scatterplots for the predicted values of each variable for the two samples we find that there is very little difference in the way the two equations measure site potential from point to point (Figure 29). The correlation for the predicted values of the two variables for the Interior Sample is nearly perfect (r= -.981), while that of the Maritime Sample is also very high (r= -.904). Corresponding R^2 values for the comparisons indicate that 96 percent of the variability in each of the predicted site variables (LSITE.2P and LSITEdP) is explained by the other in the Interior Samples, while 82 percent of the variability is explained in the Maritime Sample. This indicates that Interior equations measure almost exactly the same thing, while there is some variation in the Maritime equations. We will examine these relationships further in the next section, along with the more important issue of the accuracy of the models.

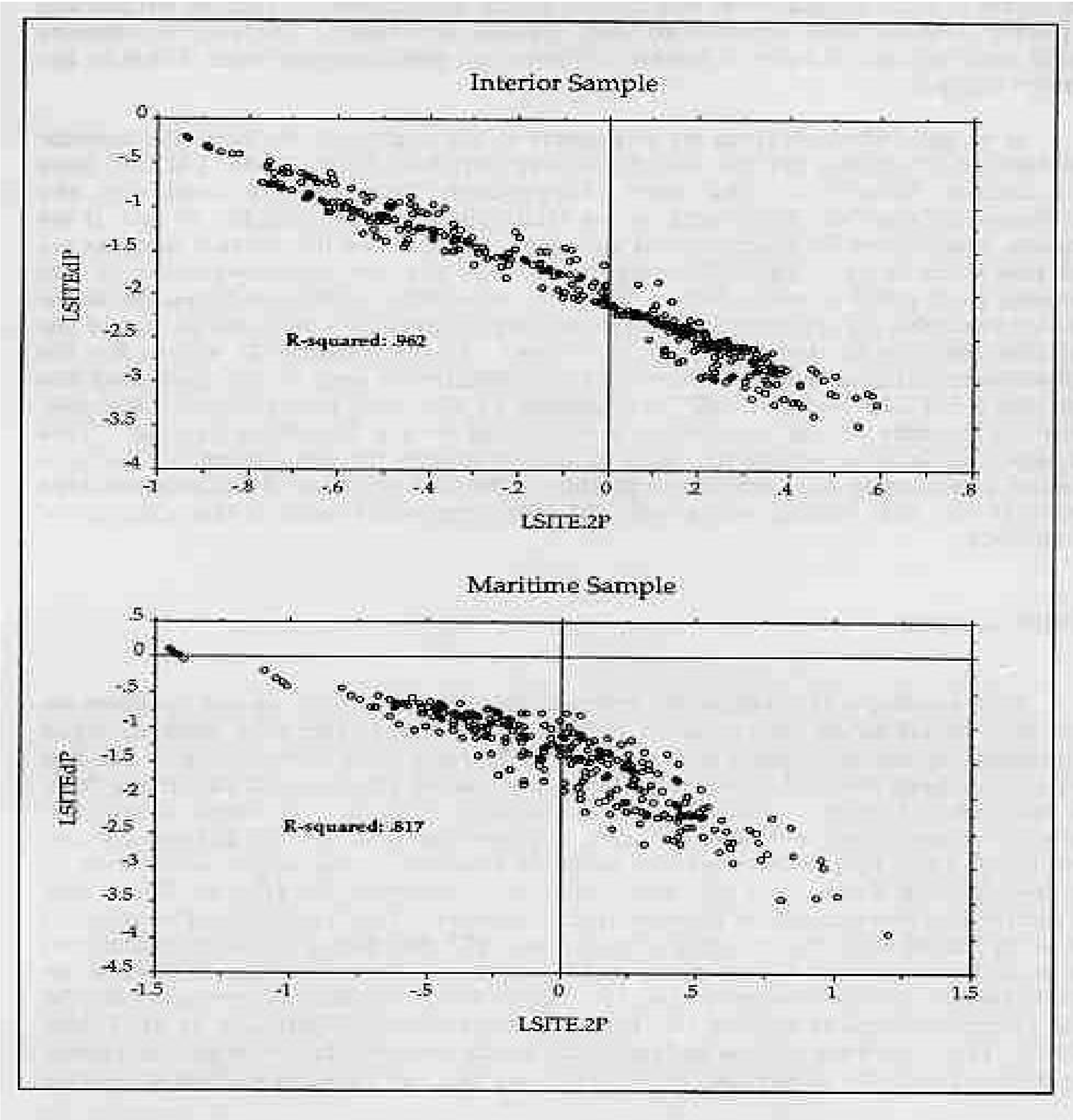


Figure 29. Scatterplots of correlations between LSITE.2P and LSITEdP for the best fit multiple regression equations

Model Testing

This section will examine the effectiveness of the models of site location we have developed using independent data from tracts of land that have received archaeological survey deploying modern site discovery field methodology. For this purpose we have selected three tracts from the Interior stratum and two tracts from the Maritime stratum. The Interior tests derive from two locations along Gal Branch and southeast of the community of Jamestown, SC on the Francis Marion National Forest (Figure 30) and one location situated in the upper watershed of Wadboo Swamp Creek near the community of Cordesville, SC (Figure 31). These are referred to respectively as Interior Tests 1, 2 and 3. Test 1 consists of contiguous stands in Forest Service Compartments 122 and 123 and Test 2 includes contiguous stands in Forest Service Compartments 122 and 140. Test 3 consists of three tracts within Forest Service Compartment 75. All of these locations were surveyed by New South Associates during the Hugo Salvage Survey (Williams et al. 1992b, 1993b). The Maritime tests were also situated in Francis Marion National Forest. The first includes the contiguous Sewee Fire and Salt Pond tracts near Forest Service Compartment 200, south of the community of Awendaw, SC (Figure 32). The former tract was surveyed by Brockington and Associates (Gardner 1992), while the Salt Pond tract was surveyed by New South Associates (Cable et al. 1995). The second test is represented by the South Tibwin tract, situated on the west side of Tibwin Creek, south and west of McClellanville, SC (Figure 33). This tract was also surveyed by New South Associates (Cable et al. 1995).

Figure 30. Project map of Interior Tests 1 and 2

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Figure 31. Project map of Interior Test 3

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The method of testing we will present in this section is essentially the same procedure one would use to evaluate an unsurveyed tract. The appropriate section of SCS soil maps are scanned and transferred to a CAD file. Then the boundaries of the development tract are rescaled and overlaid on the soil map within the CAD file. Next a grid of measurement points spaced at 0.1 mile intervals is overlaid on the soil and tract layers. It is advisable to extend the grid a good distance beyond the tract so that the skewing that occurs in contouring algorithms at the boundaries of the map data will not be manifest within the tract. The variables described in Chapter V are then measured and recorded at each grid node and these data are entered onto a spread sheet file. Once the spread sheet is completed it is a simple matter to calculate the predicted values of LSITE.2 and LSITEd for each node or control point using the multiple regression equations discussed above. These values can then be imported into a contouring program, we used the MACGRIDZO program here, where site potential contours can be mapped. These contour maps can then be imported into the CAD file where they can be layered into the base map to demarcate the precise locations of the site potential isotherms within the development tract. Since we know the real site distributions in the these test locations, we will also be able to view first hand how successful the equations are in modelling site location.

Before moving ahead to testing the models, however, it is necessary to define exactly what the isotherms we will generate actually represent. Since we will be using a contouring algorithm, the resulting isotherms will represent arbitrary boundaries in a continuous array of points across the landscape. We will rank these isotherms in accordance with their relative value in predicting site location according to the models, but they will not represent probability zones *per se*. Probability zones, as commonly formulated, represent polygons that contain the same probability of occurrence throughout. The probability of finding a site

at one location within the zone is the same as any other location within the zone. In our application the probability of occurrence fluctuates from one location to the next in each isotherm. Within any isotherm band, the locations closer to the next highest ranking isotherm have higher probabilities of site occurrence than locations nearer the next lower isotherm. Moreover, the data we will present do not reflect explicit probabilities of site occurrence, only relative ones. Thus, we cannot say precisely what the probability of finding a site at any specific site location will be, only that the location has a high or low ranking for site occurrence relative to other locations in the vicinity. This will become clearer as we discuss the tests below.

Figure 32. Project map of Maritime Test 1

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Figure 33. Project map of Maritime Test 2

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Interior Tests

Figures 34 through 39 illustrate site occurrence isotherms for the two predicted variables on sample grids covering the three Interior test tracts. As we discussed above, these isotherms represent arbitrary divisions of continuous values that are constructed in the same exact manner as topographic contours on a U.S.G.S. map. We have highlighted these particular isotherms as a visual aid for identifying areas of predicted lower and higher site occurrence and we have assigned ranked values of high, medium, and low site occurrence to these isotherms. It will be noted that the sample limits have been expanded from the surveyed limits in each case so that the @boundary effects? of contouring algorithms could be diminished in the main area of the test localities. The griding algorithm we used tends to project trends at the edges of the mapping field and as a consequence it can distort the magnitude of value changes here. This can create isotherms of exaggerated and misleading values along the borders of the map. Expanding the mapping field reduced the effect of this phenomenon within the surveyed areas and provided us with a reliable basis for evaluating the success of the models. The spreadsheet data bases for the three Interior Tests are presented in Appendices E, F, and G.

Interior Test 1 consisted of a grid area of 0.8 x 1.4 miles, and resulted in the recording of 135 control points (Figures 34 and 35). Both predicted variables (LSITE.2P and LSITEdP) show a large area of low site occurrence in the center of the surveyed tracts and much smaller areas of medium and high site occurrence on the northwest and northeast boundaries. Visually, the six archaeological sites identified during survey tend to be located in the high and medium site occurrence isotherms. True to the Interior equations, these latter isotherms are situated in locations of greater soil patch diversity and soil interfaces between well and poorly drained soils.

A grid measuring 1.0 x 1.8 miles was overlaid on Interior Test 2, resulting in a data base of 228 control points (Figures 36 and 37). The high and medium site occurrence isotherms for LSITE.2P and LSITEdP are most prevalent on the eastern side of the grid. This portion of the grid contains a number of small stream drainages, ecotonal soil interfaces, and high soil patch diversity. The western side of the grid, by contrast, consists primarily of large patches of drainage rank 3 soils and low soil patch diversity. While there is a general agreement of site occurrence isotherms and the distribution of the 18 identified sites in the survey tracts, there are also two anomalous disjunctions.

First, the northern area of low occurrence contains an unusually large number of sites. This is an area that also contains small streams, but the general soil structure is of fairly low soil drainage diversity. One factor that may be at play here is variation within a single soil drainage rank. Three separate soil types (Wahee loam, Lenoir fine sandy loam, Lynchberg fine sandy loam) of drainage rank 3 occur in this general area and it is quite possible that one or more of these soil types differ significantly in their drainage characteristics. If we were to have access to more specific data on soil drainage we might find that these soils represent a gradation of drainage that would place them at intermediate positions between ranks 2 and 4. This situation might indicate a greater diversity of soil drainage patches than our present data can distinguish and thus explain the unexpectedly large number of sites in this particular location.

Figure 34. Distribution of LSITE.2P, Interior Test 1

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Figure 35. Distribution of LSITEdP, Interior Test 1

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Figure 36. Distribution of LSITE.2P, Interior Test 2

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Figure 37. Distribution of LSITEdP, Interior Test 2

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Figure 38. Distribution of LSITE.2P, Interior Test 3

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Figure 39. Distribution of LSITEdP, Interior Test 3

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Secondly, there is an area of predicted high site occurrence in the center of the survey tracts that does not contain sites. An inspection of the soil map at this location reveals that all conditions are present that would lead us to anticipate high to medium site occurrence, including high soil patch diversity and ecotonal interfaces. This may point to some aspect of site location not well defined by the models. Alternatively, it could indicate sampling error wherein the presence of sites were mistakenly undetected by 30 meter interval shovel testing. This is a common problem with shovel testing as a site discovery technique (Krakker et al. 1983; Nance and Ball 1986; Lightfoot 1986; McManamon 1984).

Interior Test 3 consisted of a 1.4 x 1.6 mile grid of 255 control points (Figures 38 and 39). There is a general tendency in this test area for identified sites, of which there are 10, to be associated with the high and medium site occurrence isotherms as well. The LSITE.2P distribution appears to predict site location better than does the LSITEdP distribution. Half of the sites in the latter distribution are actually situated in the low occurrence isotherm, but we also see that these particular sites are located very near the medium occurrence isotherm. As such, this area is characterized by high site occurrence values relative to the entire distribution of the low occurrence isotherm. Selection of different contour intervals would distinguish these particular locations from areas of lower site occurrence.

This points to an aspect of the isotherms that must be appreciated. There are no single contour values that distinguish one occurrence isotherm from another. We selected isotherms that tended to divide the map fields into relatively equal areas of site occurrence. Other divisions, of course, could be made. The objective, however, was to break the fields into isotherms that would supply analytical advantage in distinguishing the occurrence characteristics of relatively large areas. Exaggerating the distribution of any particular isotherm will tend to dilute our ability to identify and differentiate isotherms of significant size for planning purposes.

Although there is an intuitive appreciation of the effectiveness of the models to predict site location, we need a basis for quantitatively evaluating this. One method that is at once straight-forward and also capable of controlling for representativeness, consists of comparing site densities by isotherm area. If the models are effective in distinguishing site occurrence divisions, then we would expect higher site densities in isotherms of higher site occurrence ranking. We examined this hypothesis by measuring the area covered by each isotherm *within the surveyed tracts* in each test location and calculating the site frequency density for each. Tables 38 and 39 present the results of this analysis for the distributions of LSITEdP and LSITE.2P as depicted in Figures 34 through 39. We see that both models conform very well to this hypothesis. The high site occurrence isotherms are characterized by the highest site densities, while the medium and low site occurrence isotherms contain respectively intermediate and low site densities.

A statistical test of these results can be obtained by comparing the proportions of archaeological sites and areas of site occurrence isotherms for each test location. This is essentially the same comparison as site density, but it has been reformatted to accommodate the structure of a Chi-square test. The raw data are presented in Table 40 and the results of the Chi-square tests are presented in Table 41. All comparisons are statistically significant and have associated Cramer=s V values that indicate moderately strong to very strong relationships. This confirms our general hypothesis that site density is highest in high occurrence isotherms and lowest in low occurrence isotherms. The progression, however, is not completely linear in form, because the distinctions between the medium and high occurrence isotherms are not as clear. Table 42 presents the results of Chi-square tests comparing site densities between the high and medium site occurrence isotherms only. Here we see that not all comparisons are significant, but that the LSITE.2P variable shows greater discriminatory power. Two of the three are statistically significant in the LSITE.2P comparisons and the direction of change is as hypothesized (ie. higher site densities are obtained in the high site occurrence isotherm). Only one comparison is significant in the LSITEdP variable.

From these comparisons we can conclude that the models are very effective in discriminating low site occurrence from medium and high site occurrence. However, there is a lesser degree of success in discriminating medium from high occurrence isotherms. Only one of the three tests could differentiate high and medium site occurrence using the distribution of LSITEdP values. The LSITE.2P distribution was more effective in distinguishing these isotherms, as two of the three comparisons were consistent with our expectations. We can suggest that over the long run the LSITE.2P variable will be successful in making the distinction between medium and high site occurrence, but the same conclusions cannot be made for LSITEdP. As such we would recommend the use of the LSITE.2P variable in predicting site location on Interior tracts.

Table 38. Site density for LSITEdP by site occurrence isotherm, Interior tests.

Test Location	Area (acres)	Sites(n)	Site Density/per acre
Interior Test 1			
High	7	1	0.143
Medium	29	3	0.103
Low	109	2	0.018
Interior Test 2			
High	113	6	0.053
Medium	320	7	0.022
Low	357	5	0.014
Interior Test 3			
High	20	1	0.050
Medium	193	9	0.050
Low	38	0	0.000

Table 39. Site density for LSITE.2P by site occurrence isotherm, Interior Tests.

Test Location	Area(acres)	Sites(n)	Site Density/per acre
Interior Test 1			
High	3	1	0.330
Medium	62	4	0.065
Low	80	1	0.013
Interior Test 2			
High	136	7	0.051
Medium	350	6	0.017
Low	304	5	0.016
Interior Test 3			
High	33	3	0.091
Medium	105	7	0.067
Low	111	0	0.000

Maritime Tests

Figures 40 through 43 illustrate the site occurrence isotherms for the two Maritime tests. Test 1 consists of a 1.0 x 1.4 mile grid overlaid on the contiguous Sewee and Salt Pond tracts. The data base contains 165 control points and is presented as Appendix H in the back of this report. Test 2 is a grid of 1.3 x 1.3 miles overlaid on the South Tibwin tract. This data base contains 196 control points and is presented as Appendix I.

Table 40. Proportional comparison of archaeological site area and area of site occurrence isotherms, Interior Tests.

	LSITEdP		LSITE.2P	
Test Location	% Sites	% Area	%Sites	%Area
Interior 1				
High	17	5	17	2
Medium	67	20	50	43
Low	17	75	33	55
Interior 2				
High	33	14	39	17
Medium	39	41	33	44
Low	28	45	28	39
Interior 3				
High	10	8	30	13
Medium	90	78	70	42
Low	0	15	0	46

Table 41. Results of Chi-square comparisons of percentage of archaeological sites by percentage of site occurrence isotherm areas, Interior Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	CV	df	X^2	p*	CV
Interior 1	2	68.5	0.0001	0.58	2	17.9	0.0001	0.30
Interior 2	2	11.7	0.0029	0.24	2	12.0	0.0025	0.25
Interior 3	2	16.1	0.0003	0.28	2	59.7	0.0001	0.55

* Significant comparisons are underlined

Table 42. Results of Chi-square comparisons of percentage of archaeological sites by percentage area for high and medium site occurrence isotherms only, Interior Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	Phi	df	X^2	p*	Phi
Interior 1	1	0.0	0.979	0.00	1	8.4	0.0038	0.27
Interior 2	1	5.6	0.018	0.21	1	9.4	0.0022	0.27
Interior 3	1	0.3	0.873	0.01	1	0.8	0.3972	0.07

* Significant comparisons are underlined

Test 1 is characterized by large and numerous sites, including Salt Pond Plantation, a late eighteenth-early nineteenth century out plantation containing also a prehistoric Mississippian village and Sewee Shell Ring, a Late Archaic ceremonial mound site. The mapping of both the LSITEdP and LSITE.2P variables show a fairly close correspondence between site distributions and site occurrence isotherms (Figures 40 and 41). The low occurrence isotherm contains only portions of small numbers of sites, while the medium occurrence isotherm includes most of the identified sites. The high occurrence isotherm is limited to the area around an intermittent marsh creek in the southern portion of the test field. Although it contains fewer sites than the medium occurrence isotherm, intuitively it would appear to contain a higher site density nonetheless.

Test 2 also contains a large number of sites. The largest of these are Mississippian village and hamlet segments. In contrast to Test 1, though, it also contains large void areas. Again, the bulk of the identified sites are situated in either the medium or high site occurrence isotherms (Figures 42 and 43). One anomaly is the concentration of large sites along Tibwin Creek and the salt marsh in the southern segment of the project area. This is an area of broad, relatively poorly drained soils of drainage rank 3 and the soil patch diversity as a result is low. This can be seen as a potential source of error in the model, as some locations of this sort will obviously have relatively high site density. However, the model intuitively appears to characterize site densities fairly well.

We will examine the effectiveness of the Maritime models for predicting site location in the same way we did for the Interior tests. Some modifications are in order, however, because of the large sizes of some of the sites in the tracts. This presents a problem because it often results in sites extending into two different isotherms. The solution we arrived at was to estimate the proportion of sites residing in each isotherm and crediting that fraction to the sum of sites for a particular isotherm. Fractions were calculated in 0.25 site increments. Another adjustment made to control for large sites in the Maritime sample was to calculate total site area within each isotherm. This resulted in two density measures, adjusted site frequency density and site area density.

Tables 43 and 44 present the site density data for the isotherms of site occurrence for LSITEdP and LSITE.2P. Both density measures show the expected increase from low to high site occurrence isotherms. Adjusted site frequency density tends to show a more consistent progression than site area density. In the latter case the densities for the medium occurrence isotherm overlap, at times, with both low and high occurrence isotherms.

Converting the density data to proportional data in Table 45 allows us to examine these associations from a statistical standpoint using Chi-square comparisons. Almost all of the 2 x 3 contingency table comparisons indicate significant and strong relationships (Table 46), confirming the general hypothesis that higher site densities will occur in medium and high site occurrence isotherms. The one exception is the comparison of site area density for LSITEdP in Maritime Test 1. Again, the models are less successful at discriminating medium from high occurrence areas. None of the 2 x 2 contingency table analyses comparing these two isotherms are significant for LSITEdP (Table 47). However, the comparisons of LSITE.2P for Maritime Test 2 did produce significant and strong results. Just as was true of the Interior models, LSITE.2P exhibits a greater degree of discrimination. This equation successfully discriminates low occurrence areas and appears to have greater potential for distinguishing between areas of medium and high site occurrence. Finally, site frequency density is more accurately characterized by the model equations than is site area density.

Figure 40. Distribution of LSITE.2P, Maritime Test 1

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Figure 41. Distribution of LSITEdP, Maritime Test 1

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Figure 42. Distribution of LSITE.2P, Maritime Test 2

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Figure 43. Distribution of LSITEdP, Maritime Test 2

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Table 43. Site frequency, site area and respective densities by LSITEdP site occurrence isotherm, Maritime tests.

Test Location	Area(ac)	Sites(n)	Site Area(ac)	Freq. Density	Area Density
Maritime Test 1					
High	33	3.5	6.66	.106	.202
Medium	192	14.0	40.96	.073	.213
Low	55	0.5	7.68	.009	.140
Maritime Test 2					
High	101	7.5	8.70	.074	.086
Medium	112	7.0	4.61	.063	.041
Low	226	5.5	7.17	.024	.032

Table 44. Site frequency, site area and respective densities by LSITE.2P site occurrence isotherm, Maritime tests.

Test Location	Area(ac)	Sites(n)	Site Area(ac)	Freq. Density	Area Density
Maritime Test 1					
High	24	3.75	9.10	.156	.379
Medium	163	13.25	38.03	.081	.233
Low	93	1.00	8.17	.011	.088
Maritime Test 2					
High	81	10.50	8.70	.130	.107
Medium	132	4.00	4.10	.030	.031
Low	226	5.50	7.68	.024	.034

Table 45. Proportions of archaeological site frequency and site area density by area of site occurrence isotherm, Maritime tests.

	LSITEdP			LSITE.2P		
Test Location	% Sites.	% Site Area	% Iso. Area	%Sites	%Site Area	%Iso. Area
Maritime 1						
High	19	12	12	21	16	9
Medium	78	74	69	74	69	58
Low	3	14	20	5	15	33
Maritime 2						
High	38	42	23	53	42	18
Medium	35	23	26	20	20	30
Low	28	35	52	30	38	52

Table 46. Results of Chi-square comparisons of proportions of archaeological site frequency and area by proportion of isotherm area, Maritime Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	CV	df	X^2	p*	CV
Maritime 1								
Freq.	2	14.7	<u>.0006</u>	.27	2	27.4	<u>.0001</u>	.37
Area	2	1.2	.5410	.08	2	9.66	<u>.0080</u>	.22
Maritime 2								
Freq.	2	12.2	<u>.0022</u>	.25	2	25.1	<u>.0001</u>	.35
Area	2	9.05	<u>.0108</u>	.21	2	13.8	<u>.0010</u>	.26

* Significant comparisons are underlined

Table 47. Results of Chi-square comparisons of proportions of archaeological site frequency and site area by proportion of area of medium and high site occurrence isotherms only, Maritime Tests.

	LSITEdP				LSITE.2P			
Location	df	X^2	p*	Phi	df	X^2	p*	CV
Maritime 1								
Freq.	1	0.7	.4030	.06	1	2.0	.1620	.11
Area	1	0.3	.8740	.01	1	0.8	.3730	.07
Maritime 2								
Freq.	1	0.3	.5800	.05	1	14.7	.0001	.35
Area	1	3.5	.0590	.18	1	10.0	.0016	.30

* Significant comparisons are underlined

Limitations and Extensions of the Models

One of the more eloquent features of regression equations is that they provide a basis for predicting actual values of the dependent variable for any case. The models we have discussed, then, have the potential to supply us not only with zones of ranked site occurrence, but also with data on the expected site density at any single location in the Charleston Harbor watershed. This has dual ramifications. First, it can provide developers with a ballpark estimate of the numbers archaeological sites that may be present in their tracts. Second, it can facilitate archaeological research dealing with questions of land use intensity in various localities and microenvironments.

The test locations can again be used to evaluate the equations in terms of their effectiveness for estimating site density or prevalence. An initial comparison of the predicted (SITEdP and SITE.2P) and actual(SITEdA and SITE.2A) values for the dependent variables of the control points in the test localities does not indicate that the equations are of much use in characterizing true site densities. First of all, correlations between the variables are weak and only about half of them show significant regression relationships (Table 48). The raw data for the comparisons in Table 48 are presented respectively in Appendices J and K. Only those control points within the boundaries of the surveyed areas were included as these were the only locations where actual data for the dependent variables could be collected. The weak correlations indicate that our equations do not provide a firm basis for predicting site occurrence values at a specific point. Moreover, Table 49 indicates that the equations characteristically overestimate site density (SITE.2) and underestimate distance to nearest site (SITEd). Furthermore, most of the predicted variable samples are statistically different from the corresponding actual values (Table 50). For all of these comparisons the dependent variables were transformed from LOG10 to real values.

Precisely why the actual site occurrence values of the control points in the tests are overestimated by the equations is a matter of conjecture. However, it is likely that this results from an unrepresentative emphasis on points containing archaeological sites in the model samples. The influence of this practice, which was necessary to achieve a clear reading of the characteristics in the environment that associated with our dependent variables, on the equations can be readily appreciated. A large sample of SITEd values of 0 will tend to reduce the average nearest distance to sites and, since sites are clustered, we can surmise that there is a bias toward larger site density values in the model samples. The Maritime 1 test is the only one of five where the general trend is reversed. This was an unusually dense location to begin with and also rather special since it included in its site inventory Sewee Shell Ring, Salt Pond Plantation, and a relatively large Mississippian village. It is our hunch that Maritime 1 is not truly representative of the coastal environment as a whole and that Maritime 2 actually provides a better approximation of representative conditions.

Table 48. Correlations of predicted and actual site variables from test localities.

Test Locality	Comparison	r	R^2	F	p*
Maritime 1	SITE.2A vs SITE.2P	.230	.054	2.416	.1276
	SITEdA vs SITEdP	.024	.001	0.023	.8796
Maritime 2	SITE.2A vs SITE.2P	.341	.116	9.330	.0032
	SITEdA vs SITEdP	.298	.089	6.945	.0103
Interior 1	SITE.2A vs SITE.2P	.512	.262	8.519	.0075
	SITEdA vs SITEdP	.402	.162	4.632	.0417
Interior 2	SITE.2A vs SITE.2P	.135	.018	2.010	.1591
	SITEdA vs SITEdP	.168	.028	3.150	.0788
Interior 3	SITE.2A vs SITE.2P	.227	.052	1.469	.2360
	SITEdA vs SITEdP	.511	.261	7.778	.0107

* Significant (at .05 p) regressions are underlined.

Table 49. Summary statistics for predicted and actual site variables from test localities.

	SITEdA	SITEdP	SITE.2A	SITE.2P
Maritime 1	0.053_0.056	0.065_0.106	1.773_1.516	1.113_0.735
Maritime 2	0.147_0.125	0.020_0.025	1.066_1.382	2.490_1.782
Interior 1	0.144_0.093	0.009_0.004	0.673_0.857	0.893_0.217
Interior 2	0.199_0.124	0.025_0.023	0.571_0.867	0.975_0.609
Interior 3	0.113_0.087	0.016_0.023	0.879_0.995	1.162_0.458

The consistent trend toward over representation, though, suggests that it is possible to correct for this problem and to bring the predicted values into agreement with actuals using simple regression analysis. Reversing the order of prediction this time by designating the actual values as the dependent variables (SITE.2A and SITEdA) and the predicted values as the predictor or independent variables (SITE.2P and SITEdP), we can solve for a third variable (SITE.2Pc and SITEdPc) that we can call the corrected dependent variable. Using the data in Appendix J, we can derive the following equations to correct predicted values for the Interior Sample:

(1) SITE.2Pc = .31 + (.333 x SITE.2P) and (2) SITEdPc = .15 + (1.352 x SITEdP)

The corresponding regressions are weak (R^2 = .041 for SITE.2Pc and .056 for SITEdPc), but we are not interested here in the effectiveness of the equations to predict the exact value of individual points. We know from our study of site occurrence by isotherm area that the models are capable of identifying areas of differential site density. Instead, we are most interested in determining if the new equations can reduce the predicted mean values of the test localities to levels more in line with the actual values.

Table 50. Paired t-Test comparisons for predicted and actual site data, test localities.

Test Locality	Comparison	t-score	Probability
Maritime 1	SITE.2A vs SITE.2P	2.872	.0063
	SITEdA vs SITEdP		0.6540.516
Maritime 2	SITE.2A vs SITE.2P	6.591	.0001
	SITEdA vs SITEdP		8.983.0001
Interior 1	SITE.2A vs SITE.2P	1.456	.1578
	SITEdA vs SITEdP		7.486.0001
Interior 2	SITE.2A vs SITE.2P	4.358	.0001
	SITEdA vs SITEdP		40.817.0001
Interior 3	SITE.2A vs SITE.2P	1.526	.1383
	SITEdA vs SITEdP		6.172.0001

* Significant (at .05 p) regressions are underlined.

Table 51 presents the results of calculating this new variable for the Interior tests using the equations stipulated above. As one can see, the mean actual and predicted values correspond fairly closely with this correction. The standard deviations are reduced substantially due to the averaging effects of the regression equations, but in each case there is significant overlap between the ranges of the two variables (Figure 44) and we can tentatively conclude that these correction equations are effective in adjusting the magnitude of the predicted site occurrence variables so that they more accurately reflect actual values.

Unfortunately we could not derive a set of correction equations from more than one of the Maritime tests, because of the non-representative nature of the Salt Pond-Sewee Fire tract locality. We generated two additional regression equations using the more representative Maritime 2 test. These took the following form:

(1) SITE.2Pc = .408 + (.264 x SITE.2P) and (2) SITEdPc = .117 + (1.469 x SITEdP).

Since only one data base was used in the formulation, the resulting values for the corrected variables are exactly equal to those of the actuals and this does not need further elaboration. Inclusion of additional test localities from the Maritime environment would increase the confidence we could place in the correction equation and this should probably be done in the future. At present, however, this single sample formula should be used to project densities in this stratum.

Table 51. Summary statistics for actual and corrected predicted site occurrence variables, Interior tests.

	SITEdA	SITEdPc	SITE.2A	SITE.2Pc
Interior 1	0.144_0.093	0.163_0.005	0.673_0.857	0.607_0.072
Interior 2	0.199_0.124	0.183_0.031	0.571_0.867	0.636_0.203
Interior 3	0.113_0.087	0.172_0.031	0.879_0.995	0.697_0.152

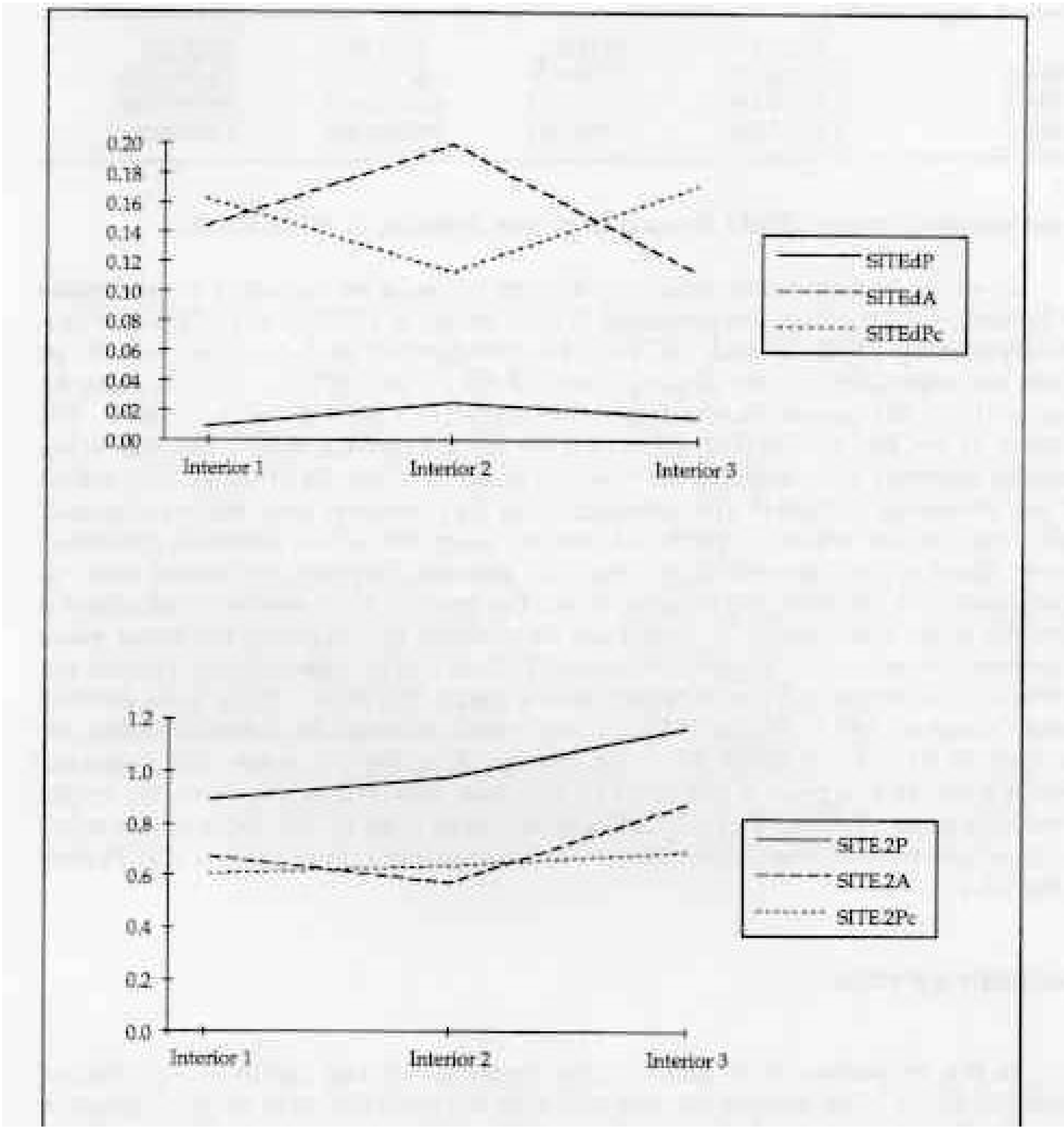

Figure 44. Comparisons of predicted corrected and actual site means

In order to derive true density estimates it would be necessary to undertake the following steps. First, the predicted LOG10 values of LSITE.2 and LSITEd, which are respectively LSITE.2P and LSITEdP, are transformed back into real values, or values corresponding to the original scales of SITE.2 and SITEd. This is done by raising 10 to the power of the individual value of LSITE.2P or LSITEdP. For instance, if we had an LSITE.2 value of 0.477 for a particular point, the real value could be obtained by calculating $10^{0.477}$, which equals 3. Once all of the LOG10 values for the predicted variables are transformed in this manner, they are transformed again into the new corrected predicted variable using one of the formulae presented above. Since we are interested in actual site density, however, we would want to focus directly on the SITE.2Pc variable. Once the mean of this variable is calculated a predicted mean site density for a tract can be obtained by refiguring the mean value by density per acre. The original variable SITE.2, it will be remembered, reflects the density of sites within a 0.2 mile radius, which equals 25.6 acres. Thus, if we derived a mean value of .607 _ .072 for SITE.2Pc, we would calculate an estimated mean for the tract of 0.0237 _ 0.00281 sites per acre by dividing the mean and standard deviation by 25.6 acres. If the tract in question was 470 acres, then, we could reasonably expect to find 11.14 _ 1.32 archaeological sites in this locality. In other words, at a 95 percent level of confidence we can expect to find between 8 and 14 sites on the tract.

Concluding Remarks

In this chapter we have presented the methodology and results of a predictive modelling effort. The method used to construct the models was multiple regression analysis. We also tested the effectiveness of the models against independent data bases from surveys not included in the formulation of the models. Testing revealed that all of the models were quite successful in discriminating locations of low site occurrence from other locations. The models were less successful at differentiating medium from high occurrence areas. However, the LSITE.2 equations effectively distinguished these occurrence zones in three of five tests. The other two tests showed no difference. This would suggest that, over the long run, the LSITE.2 equations will provide the greatest degree of discrimination and accuracy as a basis for predicting site location in the Charleston Harbor watershed. In addition, we were able to design a method for predicting actual site densities. Besides presenting a review of the procedure for applying the models, the final chapter will discuss some other ramifications, including larger regional patterns of site distribution that are not easily understood from the minute scale of analysis that we have been concerned with in this chapter. This information will also be of use in conserving and developing the Charleston Harbor watershed.

VIII. Review and Conclusions

This final chapter will briefly review and discuss the ramifications of the predictive models we have generated as a consequence of this study. The descriptions and evaluations presented in the preceding chapters have all been of a highly technical nature, as is necessary when dealing with such a complex and involved problem. Here, we will forego most of the jargon and statistical methodology laid out as a proof of the effectiveness of the models so that we can provide planners and other interested individuals with an easily understood application guide. Before we do this, however, we will briefly discuss some of the broader regional patterns of archaeological site distribution in the Charleston Harbor watershed that are of general interest to development concerns.

Regional Patterns

Throughout this report we have focused on a very fine scale of archaeological site locational patterning. Under such miopic circumstances it is easy to loose an appreciation for the larger and more obvious patterns of site location that are of equal importance in planning development and devising strategies of conservation. In the initial stages of our research we gathered a set of regional data that have very important ramifications for understanding site locational variability in the Charleston Harbor watershed.

As part of our overall evaluation of survey coverage we calculated the actual area surveyed for all of the modern surveys prior to a cut-off point during the year 1994 in the larger project area. This sample was comprised of the Hugo-Salvage Surveys on the Francis Marion National Forest (Williams et al. 1992a, 1992b, 1992c, 1993a, 1993b, 1993c), a series of 19 other large surveys of privately developed property around the coastal fringe of the City of Charleston and additional Forest Service surveys. The latter included the Sewee Fire Tract (Gardner 1992), 2,012 acres in Wambaw District (Wheaton 1990), and the Salt Pond-South Tibwin (Cable et al. 1995) surveys. The private development tracts included Brickyard Plantation (Espenshade and Grunden 1989), Charleston National Golf Course (Brockington et al. 1987), Dewees Island (Espenshade et al. 1987), Harbor Watch (Judge and Drucker 1989), Hibri Plantation (Eubanks and Bailey 1993), Hobcaw Plantation (Brockington (1987), Jenkins Point (Poplin 1989a), Kiawah Island (Trinkley 1991), Long Point (Adams et al. 1991), Molasses Creek Plantation (Martin et al. 1987), Palmetto Fort (Espenshade and Poplin (1988), Parker Island (Southerlin et al. 1988), Rhett=s Bluff (Poplin 1989b), Seaside Farms (Adams and Trinkley 1993), Sunset Point (Drucker and Jackson 1988), and Tea Farm (Adams and Trinkley 1991). Many of these were later used in our modelling effort in one context or another.

The total area surveyed in this sample amounts to about 46,986 acres, which equals a somewhat astonishing 3.41 percent of the combined areas of Charleston and Berkeley counties. Granted, a large proportion of this figure belongs to the Francis Marion National Forest, but private developers have been responsible for surveying nearly 7,700 acres on their own. There are some biases evident in the sample. The most obvious is that the entire inland portion derives from the Francis Marion National Forest, predominantly in Berkeley County. On the other hand, the private developer surveys are predictably concentrated on the coast, or just inland from it. When we look at the distribution of surveys along the coast, though there is a relatively continuous representation from McClellanville, SC to Kiawah Island. The only coastal void within the greater Charleston Harbor watershed is located in the Wadmalaw-Johns Island vicinity and portions of Edisto Island. The primary void in the sample includes the inland tracts of Charleston and Dorchester counties.

The consistent and systematic site discovery methodology employed in these surveys makes it possible to begin to estimate archaeological site density in the larger project area. Although this could be approached using simple site counts as we have done above, this would be misleading for planning purposes because it does not reflect variation in site size. Obviously the size of sites is a much more accurate indicator of archaeological sensitivity. Table 52 summarizes the site area density values for the six large survey areas of the Hugo-Salvage project and the private developer tracts, which are combined for this comparison into a single unit of analysis. This information is broken down in Appendix L at the back of this report for those who would like more detailed information on individual tracts.

Table 52. Site area data for grouped survey locations from modern surveys in Charleston and Berkeley counties.

Group	Mean	Standard Deviation
Bethera	2.89	_ 5.64
Cainhoy	1.33	_ 3.18
Coastal	3.93	_ 5.57
Huger	1.32	_ 1.92
Santee	2.62	_ 3.83
St Stephens	2.10	_ 2.35
Private Tracts	5.94	_ 8.35

The mean values in the table are expressed as percentages of acreage containing archaeological sites. What we see here is that mean site densities range from lows of about 1 to 2 percent of the area in upland tracts such as Cainhoy and St.Stephens to nearly 4 to 6 percent of the area in coastal locations (ie. Coastal Group and Private Tracts). The standard deviations increase with increased site acreage also, which indicates that there is a greater disparity of site sizes in the coastal and intermediate areas such as the Santee and Bethera Groups. In other words, higher means appear to be the result of a greater proportion of larger sites. Some of the coastal tracts, in fact, are characterized by site area densities upwards of 15 to 20 percent of the landscape. The larger mean of the Private Tracts group compared with the Coastal Group from the Francis Marion Forest may also suggest that site area density increases towards Charleston, a somewhat predictable outcome.

Viewing these density patterns on a geographic scale provides us with good evidence that the larger sites have clustered distributions. Figure 45 shows the individual site area densities for all of the surveyed timber stands represented in the Francis Marion surveys. The darker shaded stands represent the greatest densities. In general the highest site area densities occur in association with streams and other kinds of hydric features (ie. salt marsh, swamps, etc.) This is not completely illustrated by the figure as the vast swamp formations in the center of the Forest are not shown. What can be discerned, however, is that the central swamp area contains very few sites, but sites are aggregated around the perimeter of these swamps and bays, generally next to creek heads and streams. Moreover, there is a linear orientation to the site density distributions, which are aligned in a northeast-southwest direction. These alignments correspond almost one-to-one with the underlying geological structure of the region, which consists of northeast-southwest oriented coastal terraces. These terraces were well drained due to their superior elevation and provided important transportation routes and settlement zones for both the prehistoric and historic inhabitants. In general, the greatest site area densities occur on these terrace formations in close proximity to hydric features, a pattern that we recognized at the minute scale we used for predictive modelling, but could not relate to geographic patterning at this larger scale of resolution.

This pattern would be clearly manifest if we could be afforded the opportunity to apply the models to a much larger sample of the watershed, but this would require a great deal of additional expense. Approximately two labor days are necessary to generate an occurrence map of an area equal to the size of one of the test tracts we presented in the last chapter. This includes the time necessary to scan and save the various layers of the CAD base map, to record the variables, to enter the analysis results into a spreadsheet, to calculate the predicted dependent variable, to contour map the predicted values, and to produce a final map of occurrence isotherms. Once a GIS data base has been established for the watershed it would be possible to adapt the model to this more powerful framework and produce a basin-wide map that would be detailed and cost-effective. At present we will have to limit the application to specific tracts of interest. Below we will present a brief summary of the steps needed to apply the model to individual tracts.

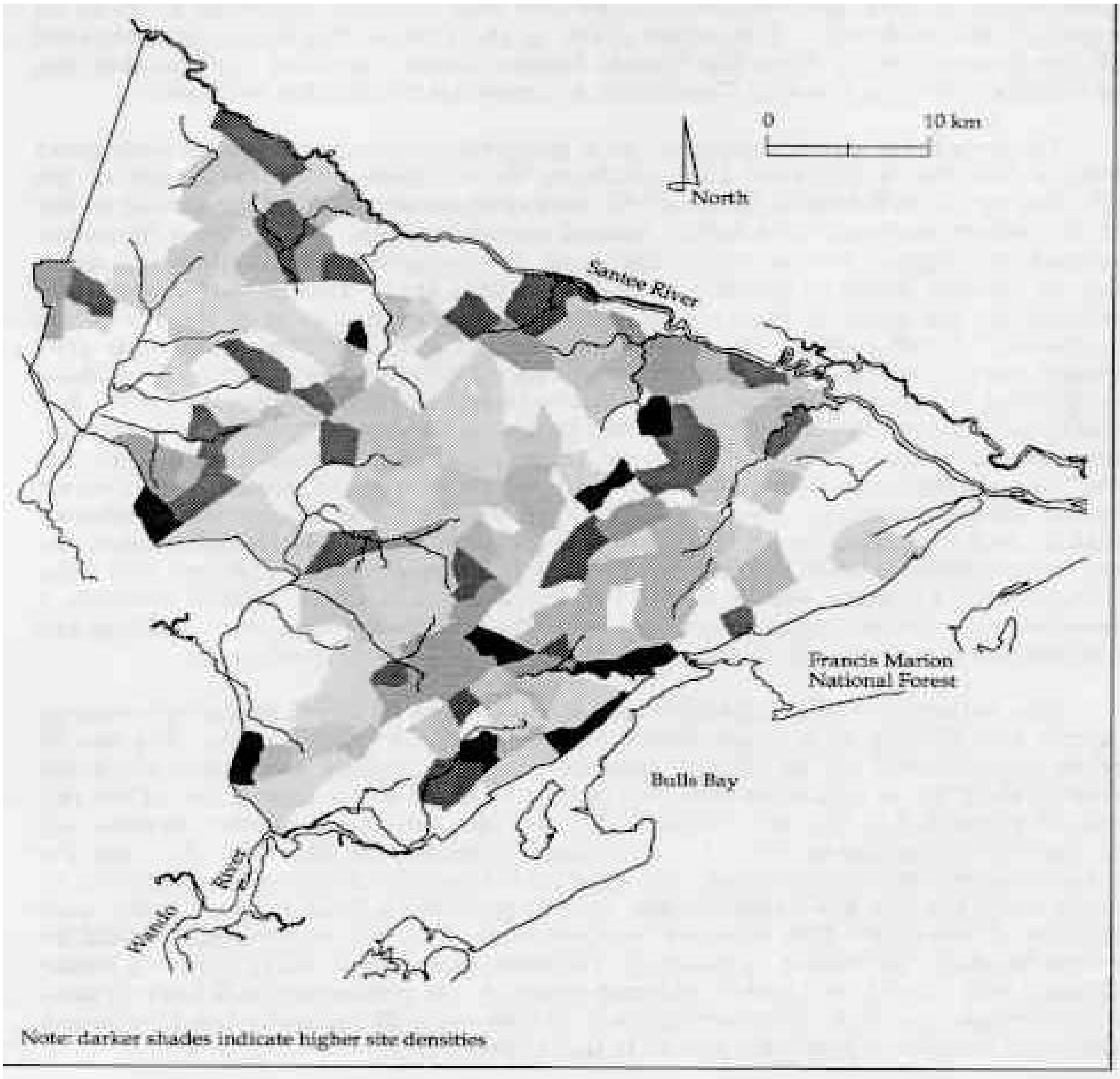

Figure 45. Site area densities by compartment, Francis Marion National Forest

Overview of the Models

The models of archaeological site location developed herein are equations. The method we used to generate the equations is a multivariate statistical technique called multiple regression. Multiple regression attempts to measure the success of a specified set of variables that we referred to as predictor variables, in the prediction of a dependent variable. We identified two independent variables that we were interested in predicting, distance to nearest archaeological site (SITEd) and site density within a 0.2 mile radius of a control point (SITE.2). Because the predictor variables were of different scales and their distributional relationships were not wholly linear we transformed the variables into LOG10 values in preparation for generating the best-fit multiple regression equations. Consequently, the dependent variables were discussed in terms of LOG10 values (LSITEd and LSITE.2) throughout most of the analysis. Best-fit models were generated for two different environments, the Interior and the coastal fringe, which we referred to as the Maritime environment. This was done because the variables we chose to measure were structured differently in the two environments.

The independent variables used in the model consisted of a subset of a more inclusive grouping of soil and stream characteristics. We found that for the Interior Sample the diversity of soil patches surrounding a control point (LHx), distance to soils of drainage ranks 4 (LDR4) and 1 or 2 (LDR1/2), distance to nearest soil interface, and distance to nearest stream (LSTd) were most instrumental in predicting the occurrence of archaeological sites, while LHx, LSTd, soil patch diversity within .05 miles of a control point (LH.05), distance to salt marsh (LDR6), distance to soils of drainage rank 1 (LDR1), and associated soil drainage rank (LDR0) were most effective in predicting sites in the Maritime Sample. Note that all of these variables have the prefix L, which means that the LOG10 transformations of each were used to generate the models.

The best-fit models explained about 50 percent of the variability in the dependent variables. This indicates that there is a good deal of variation related to site location that is left unexplained, but subsequent testing revealed that applications of the models to known survey tracts were successful in differentiating areas of high and medium site density from areas of low site density. They were not as successful in differentiating medium and high occurrence zones, but we found that the equations using LSITE.2 were more successful in this regard than those using LSITEd. Based on our tests, we can expect the LSITE.2 equations to effectively differentiate medium from high occurrence zones about 60 percent of the time. For this reason we recommend that planners and others interested in applying the models use the LSITE.2 equations for the two environments. These equations are presented here again for ease of reference:

(1) INTERIOR ZONE

LSITE.2 = -0.947954 + (-0.116274 x LSTd) + (0.852889 x LHx) + (0.090858 x LDR4) + (-0.19172 x LDR1/2) + (-0.132135 x LNEAR).

(2) MARITIME ZONE

LSITE.2 = -1.26294 + (-0.199682 x LSTd) + (3.51543 x LHx) + (-0.508256 x LH.05) + (-0.185025 x LDR6) + (0.22531 x LDR1) + (-0.972209 x LDR0).

The relative site occurrence value for any point in the Charleston Harbor watershed can be predicted using one of these equations. This is done simply by measuring the variables we have described for a point and then summing the constant, the first value in each formula, and the products of the transformed variables and their appropriate coefficients.

The method of application of the models is the same one we used in the various test cases. The appropriate section of the SCS soil maps are scanned and transferred to a CAD file. Then the boundaries of the development tract are rescaled and overlaid on the soil map within the CAD file. Next a grid of measurement points spaced at 0.1 mile intervals is overlaid on the soil and tract boundary layers. It is advisable to extend the grid a good distance beyond the tract so that the skewing that occurs in contouring algorithms at the fringes of the map data will not be manifest within the tract itself. The independent variables are then measured and recorded at each grid node as described in Chapter V and these data are entered onto a spread sheet file. Once the spread sheet is completed, it is a simple matter to calculate the predicted values of LSITE.2 for each node or control point using the multiple regression equation presented above. These values can then be imported into a contouring program, we used the MACGRIDZO program here, where site occurrence contours are mapped. These contour maps can then be imported into the CAD file where they can be layered into the base map to demarcate the precise locations of the site occurrence isotherms within the development tract.

The difference between occurrence isotherms and probability zones was discussed earlier and will be reiterated here. Since contouring algorithms were used to map the predicted dependent variable values, the resulting isotherms represent arbitrary boundaries in a continuous array of points across the landscape. These isotherms are ranked in accordance with their relative value in predicting site location according to the models, but they do not represent probability zones *per se*. Probability zones, as commonly formulated, represent polygons that contain the same probability of occurrence throughout. The probability of finding a site at one location within the zone is the same as any other location within the zone. In our application, the probability of occurrence fluctuates from one location to the next within each isotherm. Within any isotherm band, the locations closer to the next highest ranking isotherm have higher probabilities of site occurrence than locations nearer the next lower isotherm. Moreover, the data from the equations do not reflect explicit probabilities of site occurrence, only relative ones. Thus, we cannot say precisely what the probability of finding a site at any specific location will be, only that the location has a high or low ranking for site occurrence relative to other locations in the vicinity.

Through a series of adjustments and additional calculations we also showed that the models can be adapted for the purpose of estimating mean site densities. It is important to note that these estimates apply to an entire tract, since the correspondence of predicted and actual values is not great at the base level of control points. In order to calculate mean site densities it is first necessary to transform LSITE.2P back into a non-logarithm value. Once this is done a corrected predicted value for each point can be calculated using the following simple regression equation: SITE.2Pc = .408 + (.264 x SITE.2P). Mean site density per acre can then be calculated by converting the mean of SITE.2Pc from a 0.2 mile radius area (25.6 acres) into per unit acre by dividing the mean and standard deviation by 25.6. The expected number of sites for a tract can then be found by multiplying this adjusted mean and standard deviation by the amount of acreage in the tract.

Final Remarks

The predictive models discussed in this report represent tentative exploratory efforts. They explain a great deal of variation in archaeological site location in the Charleston Harbor watershed, but they leave a great deal left to explain as well. It is probable that we will not achieve a significant advance in our understanding of site location until we consider the effects of altogether new variables or newly formatted variables. We may also find that we are approaching the maximum level of resolution and we may not achieve greater clarity of patterning until we partition the universe of sites into smaller, more homogeneous groupings such as culture historic period or site functional type. Whatever the case, it should be appreciated that this effort represents a beginning for predictive modeling in the Charleston Harbor watershed, not an end in itself.

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Appendix A

Listing of Stage I Projects

For copies of these appendices, please contact the SC-DHEC Office of Ocean & Coastal Management, 1362 McMillan Avenue, Suite 400, Charleston, SC 29405.

Appendix B

Frequency of Culture Historic Components
for
Stage I Projects

For copies of these appendices, please contact the SC-DHEC Office of Ocean & Coastal Management, 1362 McMillan Avenue, Suite 400, Charleston, SC 29405.

Appendix C

Interior Sample Data Base

Stage II

For copies of these appendices, please contact the SC-DHEC Office of Ocean & Coastal Management, 1362 McMillan Avenue, Suite 400, Charleston, SC 29405.

Appendix D

Maritime Sample Data Base

Stage II

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Appendix E

Interior Test 1 Data Base

Stage II

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Appendix F

Interior Test 2 Data Base

Stage II

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Appendix G

Interior Test 3 Data Base

Stage II

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Appendix H

Maritime Test 1 Data Base

Stage II

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Appendix I

Maritime Test 2 Data Base

Stage II

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Appendix J

Site Density Data Base, Interior Tests

Stage II

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Appendix K

Site Density Data Base Maritime Tests

Stage II

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Appendix L

Site Area Density Data for Projects in Berkeley and Charleston Counties

Stage I

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